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THE ISTHMIAN CANAL COMMISSION has appointed a sub-commission to visit Colombia for the purpose of making a personal inspection of the route of the proposed Panama Canal with a view to completing the preparations for the transfer of the canal property to the United States when the final details for such transfer have been completed. The sub-committee is composed of Rear-Admiral John G. Walker, Brig.-Gen. Peter C. Haines, U. S. A., and Prof. Burr, all members of the present Commission. The committee will leave New York on April 9 for Colon, and will remain on the Isthmus for several months. They will be accompanied by Maj. William M. Black, Corps of Engineers, who has just been relieved from command of the post at Washington Barracks in order to serve under the Commission in connection with the purely engineering work of the canal project. The proposed inspection of the canal works and route will be made entirely under the auspices of the existing Canal Commission. The Panama Canal Commission, which will have charge of the actual construction of the canal under the terms of the act passed at the last session of Congress, probably will not be named until after the ratification of the canal treaty by Colombia.

THE STEAMER "MINNESOTA" is to be launched April 16 at New London, Conn. The "Minnesota" is the first of the great fleet which James J. Hill is having built for the Pacific Ocean service of the Great Northern R. R. She is 630 ft. long, 73½ ft. wide, and 56 ft. high to the upper deck. The hull is divided into 46 water-tight compartments. The steaming speed is to be 14 knots an hour, and both passengers and freight will be carried.

DELAWARE RIVER SHIP YARDS have contracts for $40,000,000 worth of ships. Of the 59 crafts being built seven are warships, costing $22,000,000.

THE NEW SCANDINAVIAN LINER, "Heilig Olav," of the Scandinavian-American Line, is making her first westward passage of the Atlantic. She is 515 ft. long, 58 ft. in breadth, and 42 ft. from keel to upper deck; her tonnage is 10,000, and her displacement 16,000. Alexander & Sons, on the Clyde, are her builders.

BIDS FOR A HIGHWAY BRIDGE across the Potomac River at Washington, D. C., were received on March 27. The bridge consists of 13 spans, one of which is a draw-span, and the bids for its construction ranged from $980,000 to $1,315,000. The itemized bids are given in our Construction News Supplement this week.

THE PHILADELPHIA RAPID TRANSIT SUBWAY was placed under construction on April 6 by the Philadelphia Rapid Transit Co. The section on which work was begun is known as Section 3 and the contractors for its construction are E. D. Smith & Co. It extends along Market St. from 15th St. to 22d St., and is to be a four-track structure.

MUNICIPAL OWNERSHIP OF THE STREET RAILways of Birmingham, England, was heartily endorsed by popular vote some time ago, but in January of the present year the city council authorized its tramway committee to negotiate for extensions of the leases under which the British Electric Traction Co. now operates in Birmingham. The leases of the company expire in 1906 and 1911, and the company has offered, and the tramway committee has recommended the acceptance of the surrender of these leases and the making of a new one for 24 years. Under the proposed new lease the company would pay the city $60,000 a year for the first three years, meanwhile changing its system to electric traction. Thereafter it would pay 7½% of its gross profits for five years, and 15% for 16 years, guaranteeing payments of at least $100,000 and $115,000 per year, respectively. Shortly after this proposition came up some London capitalists offered to convert the system to electricity in one year, and to pay the city a lump sum rental of $100,000 a year for the first three years, and $250,000 a year for the next 21 years. As the London "Surveyor" states, this proposition has naturally set people to thinking and talking, and while it may not be feasible to accept it, since the British Electric Traction Co. holds the field for some years to come, yet it may turn the current back to municipal ownership.

AUTOMOBILE SPEED RECORDS were broken on April 7 in the races held at Nice. According to press dispatches nine of the competitors in the mile standing start and kilometer flying-start events, broke the world's records for the distances. Eight of the records were made in the mile race. The best time was made by a 60-HP. Mercedes car, it covering the mile in 63 $^{18}/_{25}$ seconds. A 20-HP. Serpollet machine beat the kilometer record by a fraction, doing the distance in 29 $^{12}/_{100}$ seconds, the record made by Mr. Rolls at Welbeck, England, last February, not being recognized. Mr. Rolls did the distance in 27 seconds, but the course was downhill, and his machine was loaded to give it speed. The system of timing adopted at Nice was extraordinarily accurate, chronicling a hundredth of a second.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Cleveland, Cincinnati, Chicago & St. Louis Ry., near North Manchester, Ind., on April 1. A passenger train collided with a freight train going in the opposite direction, and two men of the train crews were killed. The cause of the wreck is not determined.

A BLAST FURNACE EXPLOSION at the Edgar Thomson steel plant of the Carnegie Co., at Braddock, Pa., on March 31, killed one man, mortally injured seven, and seriously injured seven others. The explosion occurred while the men were endeavoring to fix the electric hoist which was out of order.

MOLTEN STEEL STRIKING WATER caused a series of explosions in the plant of the Columbus Iron & Steel Co., Columbus, Ohio, April 4. The molten steel leaked through a fissure in one of the furnaces and reached a water-filled sewer nearby, resulting in an explosion which further enlarged the fissure so that several explosions followed. The last explosion blew sheets of molten steel high in the air, displaced the roof, and knocked down the end wall of the building. No one was injured. The property damage was $1,500.

DYNAMITE EXPLODED and wrecked an ore train near Santa Barba, Mexico, April 2, killing the American engineman and five Mexicans. On April 4 dynamite falling from the seat of a buggy exploded, tearing away the bottom and sides of the buggy. The accident happened near Partridge, Kan. The dynamite was in a grip said to belong to an agent for a dynamite company. No one was seriously injured.

THE OGDEN-LUCIN CUT-OFF on the Southern Pacific Ry., crossing Great Salt Lake, Utah, has recently given much trouble by portions of the embankment sinking out of sight. This cut-off line was described in Engineering News of Nov. 27, 1902; the article mentioned, among other matters, some unusual occurrences in pile driving on this work, which were chargeable to the nature of the lake bottom. The bottom is covered with a thick and hard crust of salt, though at some points exceedingly soft and treacherous bottom was encountered. These latter points gave much trouble during construction and required constant filling in as the roadbed sank in the lake. The first engine to be run over the completed line was thrown into the lake by the sinking of the track at the worst section; this was only two weeks ago, March 24. On April 2 a train was proceeding toward the gap and had reached a stretch of about 500 ft. of trestlework near the gap when the trestle sank under the load and threw the train into the lake. A thorough investigation is being made of the treacherous ground. It is thought that the channel of a former river, filled with mud to a great depth, exists at the points where the sinking took place.

Another lake-crossing reports a failure. The Rutland-Canadian Ry., described in Engineering News of Jan. 16, 1903, runs from Alburg, Vt., to Burlington, Vt., crossing parts of Lake Champlain on an embankment. Part of this structure gave way under a freight train on March 17. No one was killed or injured in the wreck.

A DAM FAILED AT ROXBURY, VT., on April 1, doing slight damage. It appears to have been a small structure furnishing power to a watch factory.

A DAM FAILED AT PORTSVILLE, DEL., on April 4, when high water carried out about 40 ft. of a structure at the mills of Capt. James Smith. But little other damage appears to have been done.

THE PASSAIC TRUNK SEWER BILL passed the New Jersey legislature just before adjournment and has been signed by the governor. It provides for a trunk sewer from Paterson to Newark and across Newark Bay and the city of Bayonne to an outlet in New York Bay. The work is to be carried out by the Passaic Valley District Sewerage Commission, and is substantially in accordance with the recommendations of the commission, which, in turn, were based on the report of Mr. Rudolph Hering, M. Am. Soc. C. E., 170 Broadway, New York city. The offices of the commission are in Newark, N. J. The bill was strongly opposed by Paterson, and it is said that its constitutionality will be attacked in the courts.

THE SLOW SAND water filtration plant at Washington, D. C., seems assured at last, contracts having been awarded as follows: Excavation and concrete work, Cowardin, Bradley, Clay & Co., Richmond, Va., $989,694; steel and cast-iron pipe and drainage system, Brennan Construction Co., Washington, D. C., $225,535; sand and gravel, L. E. Smoot, $487,855; total, $1,703,084. The cement is to be furnished by the government. The date set for the completion of the work is Dec. 31, 1904.

SILOXICON AND EGYPTIANIZED CLAY are the names of two new substances patented by E. G. Acheson, of Niagara Falls, N. Y. Siloxicon is made from sand and ground coke in an electrical furnace in the same manner as carborundum, which is also one of Mr. Acheson's inventions. Siloxicon forms at 4,500 to 5,000° F., while carborundum forms at 7,000°. Siloxicon will be used as a lining for furnaces, converters, for firebricks, muffles, etc. Egyptianized clay is made by treating clay with tannin which greatly increases the tensile strength of the product.

A DISCOVERY OF TIN is reported from Alaska, specimens of ore having been found in the alluvial deposits on Buck Creek and Grouse Creek, according to "The Pacific Coast Miner." One stratum of clay, 2 ft. thick, yielded 1 to 6 lbs. of stream tin to the gold pan. The lode from which the stream tin has come remains undiscovered.

THE DES MOINES RIVER VIADUCT OF THE MASON CITY & FORT DODGE R. R., AT FORT DODGE, IA.*

By H. C. Keith.†

The main lines of the Chicago Great Western Railway (or Maple Leaf Route, as it is called from a fancied resemblance of these lines to the main lines of a maple leaf) consisted, prior to 1901, of three lines running from Chicago, the Twin Cities of Minneapolis and St. Paul, and Kansas City, respectively, to a central point at Oelwein. In addition, there were several branches, two of which become important in connection with the new work.

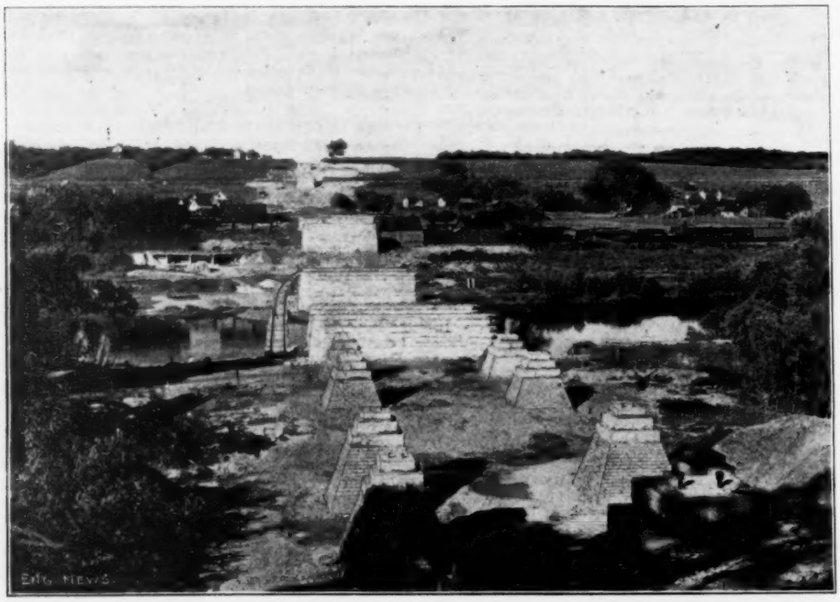


FIG. 1. VIEW OF SITE OF DES MOINES RIVER VIADUCT, SHOWING SUBSTRUCTURE COMPLETED.
H. C. Keith, Chief Engineer, Mason City & Fort Dodge R. R.
Bates & Rogers Construction Co., Chicago, Ill., Contractors.

In the spring of 1901, the management of the road purchased the Mason City & Fort Dodge R. R., and began the construction of lines running northward from Mason City to a connection with its Hayfield & Manly branch, thereby giving a direct route to Minneapolis and St. Paul. Another line, from Clarion to Hampton, connecting with the Waverly branch, gives a fairly direct connection with the line to Chicago. New lines were projected from Fort Dodge to Omaha and Sioux City, and a cut-off from Waverly to Oelwein, giving a more direct connection with the Chicago line. The new lines are built with easy curves and with maximum grades of 0.5% against the eastbound traffic and 0.7% against westbound traffic, and the old lines are being revised to give similar grades.

The line from Fort Dodge to Omaha crosses the Des Moines River valley in the city of Fort Dodge at a point where the valley is 1½ miles wide, and the river is about 160 ft. below the level of the prairie. At the site of the viaduct the line crosses the Illinois Central and the Minneapolis & St. Louis railways, the crossing of the latter being near the southerly end of its freight yard. It also crosses five highways. To avoid the freight yard of the M. & St. L. R. R. would have necessitated an increased length of line, and also an increased length of viaduct. The viaduct at this point has a total length of 2,582 ft. and a height of 138 ft.

The soil here is very uneven in make up, one excavation 15 ft. in depth having, in addition to the rich loam which makes Iowa rank first as a corn-producing state, sand, peat, coal, marl, soapstone, iron pyrites, gypsum, vermillion, sandrock, and several varieties of clay, and finally a bed of slate, all within a depth of 15 ft. The material was not in regular layers, but in layers lying irregularly, resembling marble cake, and with a variety of coloring which discounts the most brilliant rainbow the writer has ever seen.

The viaduct consists of 38-ft. towers with 75-ft. suspended spans, and four truss spans of 220 ft. each. The girders are spaced 10 ft. centers, and the posts of the towers have a transverse batter of 2 ins. per foot. The truss spans are supported on triangular or A-towers having the same spacing transversely as those for the girder spans, and a longitudinal batter of 3 ins. per ft.

SUBSTRUCTURE.—The study of the site began in July, 1901. The substructure work was done by the Bates & Rogers Construction Co., of Chicago, Ill., in the period from October, 1901, to June, 1902. The material for this work was delivered upon spur tracks connecting with the M. & St. L. R. R., one curving around toward the east and running parallel with the viaduct, the other running upon the west side of the M. & St. L. parallel with its main line, and from this the material was unloaded and reloaded on tram cars running across the river and up to the west slope to deliver at any desired point.

The abutments were made without wings, the slopes being allowed to run in front of the abutments under the end spans of the viaduct. At the river and at each railroad crossing are piers of Kettle River sandstone; the piers at the river running 20½ ft. above the ordinary water level, this bringing the freshet water level at the bottom of the top course of stone of the piers (the river rising 19 ft. and spreading from 200 to 700 ft. in width at the highest freshet of which information could be had). The railroad-crossing piers were carried up 10 ft. above the tracks of the roads crossed in order that a derailed train might spend its energy upon the masonry rather than bring the steel work down on top of it. In all other places individual pedestals were put in for each post of the towers, the top of the masonry being kept as low as practicable, for the sake of stability.

The foundation in all cases was made of concrete; and, wherever the concrete came above a plane about 4 ft. below the natural surface of the ground, the concrete was faced with paving blocks of Kettle River sandstone. Below this level the surface of the concrete was given a facing by spading in such a way as to crowd the coarser material in and force the richer mortar to the surface. Wherever the concrete was built in forms with sloping sides, the batter was made 4 ins. to the foot. The bottom of all concrete foundations was made the full size of the excavation, and the concrete was rammed hard against the walls of the excavations.

The top three courses of the piers beside the river and the railroads, and also of the pedestals, were made of Kettle River stone dressed to lay with ¾-in. joints. Below these three courses the piers were built of cyclopean rubble with stone varying from 10 to 150 cu. ft. The broken stone for concrete west of the M. & St. L. was dumped through a trestle under the west spur track and there reloaded on tram cars; the Kettle River rubble stone was dressed beside the spur track and reloaded upon cars. From these points the materials were carried across the river by a temporary track and trestle to a new delivery yard at the foot of the west hill. The concrete for all of the work on the west slope was mixed at this place and dumped into buckets which were hauled up the track on the slope by a stationary engine at the top of the hill, and delivered by derrick and engine into the excavations prepared for it. After the workmen became thoroughly accustomed to this work so that each man knew just what was expected of him, 140 yds. of concrete were placed in an excavation at the top of the hill in a day of 10½ hours. The concrete on the flats was delivered by barrows, and that near the top of the east slope was delivered by spouts; it had in no case a drop of more than 10 or 12 ft. from the barrow or spout to the bottom of the excavation.

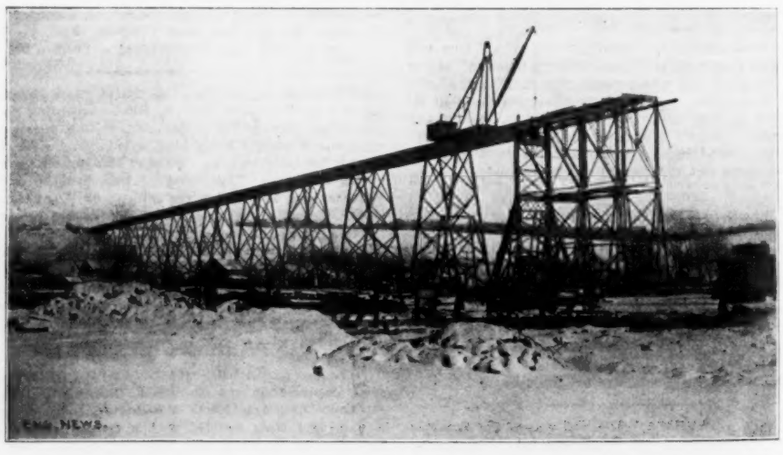


FIG. 2. VIEW SHOWING DES MOINES RIVER VIADUCT IN PROCESS OF ERECTION.

In extreme cold or changeable weather no concrete was laid, but when the temperature was not excessively changeable and was above about 20° F., concrete or stone masonry was laid, using salt in the water in the proportion of 1 lb. salt

*A paper prepared for the Iowa Engineering Society, giving the substance of an address by the author at the annual meeting of Jan. 22, 1903.

†Chief Engineer, Mason City & Fort Dodge R. R., Fort Dodge, Iowa.

to 18 gallons water at 32° F., and 1 oz. additional for each degree below 32° (the temperature used in determining the amount of salt required being taken as the lowest expected in about six hours). In freezing weather both the sand the water were warmed, but not sufficiently heated to make the mortar set too quickly.

In joining new to old work, the old surface was scabbled to give a rough surface, well moistened, and a thin layer of neat cement mortar laid, before continuing with the concrete. Generally, stones were set in the old work projecting about 6 ins. so as to serve as dowels to tie the new to the old work. No stone work was laid on the concrete until the concrete was hard (usually about a week, but varying somewhat with the weather).

In each pedestal and pier at every post, anchors were set, composed of four 8-in. I-beams running parallel with the line of the viaduct; under which were two 12-in. channels back to back, close to, and one each side of, two anchor rods 2 ins. in diameter, passing up through the masonry, with thread and nuts to secure the base of the post. At many of the pedestals there can be no uplift by

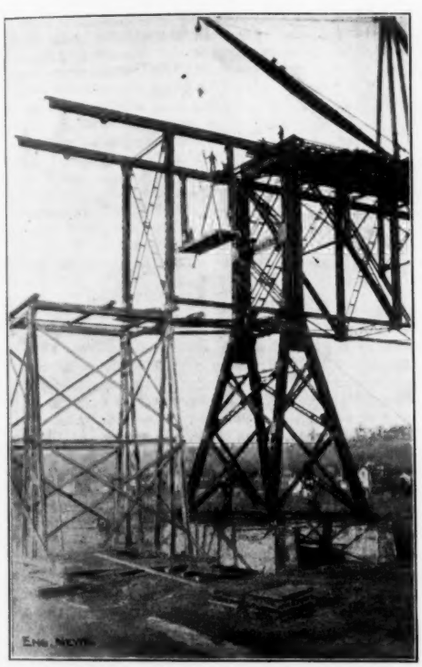


Fig. 3. View Showing A-Tower Carrying Truss Spans for Des Moines River Viaduct.

the usual rules for determining the amount of uplift, but anchors were set in each case.

SUPERSTRUCTURE.—The contract for the superstructure was given to the American Bridge Co. in December, 1901, and the work was placed in their shops as follows: the 38-ft. girders and towers were made at the Milwaukee shops; the 75-ft. girders at the American shops in Chicago; the truss spans and truss towers at the Detroit shops, except the eye-bars, which were made at the Pencoyd plant. The erection of the superstructure was sublet to the Kelly-Atkinson Construction Co.

The material was delivered at the east end of the viaduct and unloaded beside and between the tracks for a quarter of a mile east of the end of the viaduct. From this point material was taken as required; the erection beginning at the east end, using for a traveler a large derrick car running on a track with rails 10 ft. c. to c. Another derrick car on standard gage track serves as a tender for the traveler, bringing its material from the storage yards.

The first bent was bolted together "on shore" and carried forward and lowered into place by the traveler, and guyed. The girders of the first span were then placed upon it and the deck added. The traveler then moved out upon this span and erected the second bent and placed the second span of girders; and so on, proceeding until the truss spans were reached. Wherever a bent was not so high as to require splicing the posts, the bent was bolted together with its bracing upon the ground, and then raised into place by the traveler, a guy being carried forward to hold it, another guy being run back to the portion of the structure which was already up.

Where the towers were so high that the posts were spliced (if the second bent of a tower), the bottom section of one post was raised and secured to the anchor bolts; the first section of the other post similarly placed, and the bracing put in between them; then the top section of the bent was bolted together on the ground, lying transversely of the bridge, and all but one short section of bracing coupled up. Then the top section of the bent was raised from above, turned, and put into place, the omitted section of bracing below the post section to spring in enough to make connection.

The reach of the boom of the traveler being only 64 ft., and the long girder spans being 75 ft., the first bent of each tower had to be erected in a slightly different way. The lower section was put together with its bracing and raised and placed upon the masonry, being left at a slight incline so that the axis of this section of the bent pointed toward the head of the boom of the traveler. Next, the top section of the bent was put together in the way previously described for the bents erected with the 38-ft. reach, and raised and put into place (still being left on a slant so that the line of direction pointed toward the head of the boom of the traveler, until connection was made with the first section of the bent). Then guys drew the vent plumb, holding it so while the traveler returned to get a girder to place upon it.

The detail at the top of the post is so planned that the center of bearing for both spans resting upon the bent comes directly over the axis of the bent, there being a lower lip on the 38-ft. girders which form the top part of the tower, and an upper lip of the suspended span rests upon the lower lip of the tower girders. Ample support for the suspended girder spans during the erection was obtained by extending the cap plates of the posts on transverse angles stiffened by knee angles outside the body of the posts.

When the last tower for the girder spans was reached, false work bents were put up to support the last girder span and allow the traveler to move forward far enough to conveniently erect the A-tower supporting the end of the truss span. These A-towers were made with a transverse batter of 2 ins. to the foot, and so placed as to make the posts lie in the same longitudinal plane with those supporting the girder spans. Longitudinally, the posts of the A-towers have a batter of 3 ins. per ft., the apex being at the bottom pin. Where two truss spans rest upon the same A-tower, the pins are 3 ft. centers and the posts are spread that amount more. For erecting the truss spans, two bents of false work were erected from above by the traveler and braced, and the end posts and first panel bottom chord put in place then the first section of the top chord and the first panel vertical for both trusses were bolted together on the false work and raised, and sway bracing put in and subposts and truss diagonals added.

In order to erect the second sections of the top chord readily (the splice being just a little toward the end from the second full panel point), a temporary bent was added upon the false work to support the top chord and allow the floor beams and stringers to be put in up to the middle of the second panel, when a third bent of false work was put out and the second section of the cohrd and the third vertical were bolted together and raised, coupled to that which had been previously put up, and braced; and so on, completing to the third panel. In this way each truss was erected until the last full panel was reached, when the next tower was raised and braced before the last panel of the truss was put in place. The same false work was used for all the truss spans, each bent as wanted being taken from its position under the completed span, raised at the side of the truss (guys being carried out on the opposite side from the mast head to prevent overturning), and carried forward above the deck and launched into its new place.

The A-towers prove a very satisfactory arrangement for supporting the truss spans because of the reduction in the uplift, for which provision would have to be made. If towers were used like those upon the trestle part of the work, there might be a very considerable longitudinal thrust due to trains upon the 220-ft. span with only the dead load upon the tower to resist the uplift caused thereby. With the A-towers as proportioned, whenever the maximum longitudinal thrust occurs, there is also a live load to help resist it, so that in no case, according to the usual formulas for longitudinal thrust and wind pressure, can there be any uplift exerted upon the masonry for these towers.

The erection of the steel work began Oct. 8, 1902, and the structure was completed on March 10 and put in operation on March 14, 1903.

METHODS AND COST OF WATER-HOISTING IN THE PENNSYLVANIA ANTHRACITE REGION.*

By R. V. Norris,† M. Am. Inst. M. E.

The removal of mine water by hoisting in tanks instead of pumping, while somewhat a reversion to the methods of the ancients, has come very rapidly into favor in the anthracite region of Pennsylvania during the past few years. In fact, so much so, that at the present time there are at least eight large collieries at which all the water is hoisted, and six more plants in preparation.

Besides these, the Delaware, Lackawanna & Western R. R. Co. is constructing a large capacity hoist for a depth approximately 500 ft., to be located in the Keyser Valley, near Scranton. The hoists will be driven by electric motors, geared directly to the sheaves. The Lehigh Valley Coal Co. is planning a large hoist for the Packer collieries in the Shenandoah district, but no work has been done on this as yet.

The earliest regular hoisting, I believe, was done by means of semi-cylindrical tanks (Fig. 1) at the Nanticoke collieries of the Susquehanna Coal Co. These tanks were attached under the regular shaft carriages, taking in water through six large clack-valves in the bottom, and discharging through an endgate opened by a lever which was operated by a guide piece, on the shaft head frame. These tanks were designed July, 1880, by the late J. H. Bowden, one of the very early members of the Institute. Similar tanks are still used in emergencies at the Nos. 1, 2, 3 and 6 shafts of the company. The objections to their use were: that water could only be hoisted during the night shift, or when the shafts were not in use for hoisting coal, requiring a very large pump, and greatly limiting the water capacity of the plants; that the alternate wetting and drying of the shafts did considerable damage to the timber; and that the collection of ice in the main shafts, which are invariably down takes for the ventilation, endangered the men in going up and down in their work. These reasons, with the gradual increase of water beyond the capacity of the plants, led to the abandonment of this method of hoisting, so that now these tanks are only used in emergencies. The method was, however, probably one of the cheapest ever devised for handling a moderate amount of water from deep shafts, as practically the only cost was for the steam used, the extra wear and tear of engines, ropes, shaft guides and timbering, and the extra oil required for lubrication. The hoisting engineers being required by the Pennsylvania Mine Law to be in the engine houses at all times, and night firemen being necessary at all colliery plants, there is really no additional labor cost to this method of hoisting. These tanks have a capacity of 1,300 gallons each, and 50 per hour was an ordinary dump, so the total capacity from a shaft 1,000 ft. deep, was about 750,000 gallons per day of 12 hours.

The present method of hoisting from a special water shaft or water compartment was, I believe, first used in 1896, at the Luke Fidler colliery, Shamokin, by Mr. Morris Williams, then superintendent of the Mineral R. R. & Mining Co., of which Mr. Irving A. Stearns was the manager. The plan was the outcome of the successful use of tanks in unwatering the colliery, which had been flooded to subdue a mine fire.

The tanks were made to dump as shown in Fig. 2, and, to get the maximum size, were made square with angle-iron corners; it was found almost impossible to keep them tight, and round tanks have been substituted.

The original method of dumping was the use of small wheels bearing against the guides to retain the tanks in a vertical position while hoisting; these passed through slots in the guides when the main dumping wheels reached the dumping rails (Fig. 2). These small wheels, if made of iron, rapidly destroyed the guides, and if of softer material only lasted for a few hoists. The present method of handling these dumping tanks is the use of a third guide (Figs. 2 and 3) at right angles to the main guides,

*A paper read at the Albany meeting of the American Institute of Mining Engineers.

†Asst. Engr., Penn. R. R. Coal Co., Wilkesbarre, Pa.

and providing the tank (Fig. 4) with an extra shoe, set so as to give the tank a slight tilt toward the third guide; this shoe slides on the guide, keeps the tank steady and in a vertical position until the dumping wheels near the top of the tank engage the dumping rail at the top of the shaft, and the tank turns gently, pouring its contents into the discharge basin. Another great advantage of the

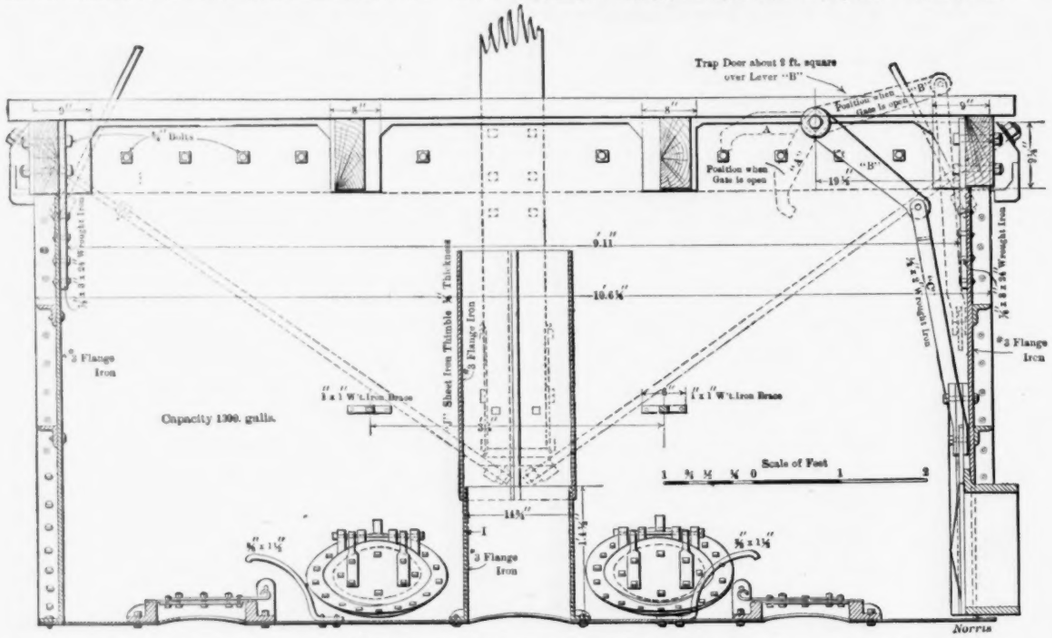

Trap Door about 2 ft. square over Lever "B"
Position when Gate is open
Position when Gate is open
Capacity 1300. galls.
Scale of Feet
Norris

FIG. 1. CAGE-TANK, SUSQUEHANNA COAL CO., NANTICOKE COLLIERIES, Nos. 5, 6 AND 7.

third guide is the steadiness it imparts to the tank and the smaller liability to accident from shaking the guides loose.

The original tanks were provided with a single, large, flat clack-valve at the bottom, which, in dumping, tended to swing to a vertical position and allow a small escape of water through it; this also struck the water very heavily in descending. The latest tanks are constructed with butterfly valves, set on a 45° angle, which entirely obviates the loss in dumping, and enters the water as a wedge with a much less severe shock (Figs. 4 and 7 to 10).

To successfully operate these dumping tanks, it is essential to arrange a rest in the sump on which the descending tank is supported while the upper tank is dumping. Without this the lower tank and rope may overbalance the upper tank, with nearly half its weight supported on the dumping track, and raise it sufficiently to reverse it in the shaft, and possibly do damage to the sheave.

The sudden reduction of load by discharging the water makes the landing a little delicate, and constitutes practically the only objection to this method of hoisting.

An automatic device is usually employed on shafts to minimize the danger from overwinds when hoisting water. The type used by the Philadelphia & Reading Coal & Iron Co. and the Pennsylvania R. R. Co. is known as the Kohlbraker & Williams overwinding device, and consists (Fig. 5) essentially of cut-off valves close to the engine cylinders and a trip lever in the shaft operated by the cage or tank, which, when struck, instantly cuts off the steam and applies the brake; this will absolutely prevent damage from overwinding due to starting the engine in the wrong direction or miscalculating the landing. It will minimize the damage caused by a runaway overwind, which, with the enormous weights and high speeds involved, could not be stopped short by anything less than the absolute wrecking of the engine

As the usual dimensions of shaft compartments are about 7 × 13 ft., it is the general custom to use only one compartment for water hoisting (Fig. 3). This compartment is divided into two parts by an extra line of buntins (when discharging at the end of the shaft), or merely putting in two sets of guides on the sides of the compartment, with the extra guides on the ends when dumping at the sides of the shaft. The arrangement of two tanks in one compartment also reduces to a minimum the extra size and cost of shaft required for water hoisting. The water-hoisting engines are usually set at right angles to the coal engines, to avoid placing one sheave over the other, with the resulting extra liability to wrecks.

Bottom-dump tanks, instead of end-dumping ones, are exclusively used by the Philadelphia & Reading Coal & Iron Co., and also by our companies, as emergency hoists in the coal compartments. These are generally constructed (Fig. 6) with the intake valve at the bottom, and are provided with a trip lever, operated by a guide in the head frame, to raise this valve at the top, and a discharge casting to direct the outflowing water to one side into basins or troughs. The various types of discharge castings and valves in use are shown in Figs. 7 to 10; in all of these it will be noticed that an effort has been made to reduce the blow (incident to striking the water) by the use of wedge-shaped castings; the Lytle Coal. Co., by the use of a wedge-shaped sheet-iron shield, outside of the discharge casting, reduce the shock still more.

The objections to this type of tank are: its unsteadiness in hoisting at high speed; slower discharge through the bottom valve (the experience at William Penn colliery having shown an advantage of 10.1% in favor of the end dump), and, greatest of all, the danger of damage to the guides caused by the slanting nose striking the water and the consequent side pressure on the tank, which is intensified by the reaction of the water entering on one side only. In our experience with both types there has been practical immunity from trouble with the guides from the end-dump hoists, and almost constant difficulty with them when the bottom-dump tanks are used. One guide at the water level forced out after 30 days' service was eaten into fully 1½ ins. by the wear of the tank guides; the cast bottoms are also more liable to breakage from striking obstructions or floating timber than are the wrought-iron tanks, the cast-valve seats of which can be made heavy enough to withstand any ordinary battering without unduly increasing the weight of the tanks.

The discharge casting (Fig. 9) is destined to minimize these difficulties; the idea was suggested to the writer by Mr. George Hill, Cons. Elect. Engr. for the Delaware, Lackawanna & Western R. R. Co. The plan is to make an open casting and take water in both sides, having a central partition which is a perfect wedge, and thus entirely avoid the side thrust due to the slanting bottom and side entry of the water. In discharging, other arrangements may be made for taking care of the double discharge; or, where this is undesirable, only one valve may be opened, making the discharge in all respects similar to that at present used. To compensate for the disadvantages above mentioned the bottom-dump tanks do not require any special shaft or dumping preparation; the costly complication of mounting them on trunnions with a through shaft and stuffing boxes is avoided; and the difficulty of landing, due to the sudden change of load, as before mentioned, is much reduced.

While all the regular water hoists are in shafts, very large quantities of water have been hoisted from slopes in emergencies. The tanks are usually of the end-dump type, and have done excellent work. The principal objections to their regular employment are: the rapid wear of the wheels caused by acid mine water working into the bearings and replacing the oil; the slower hoisting speed necessary for tanks running on wheels, as compared with those in shafts sliding on guides; the liability to derailment at any point of the hoist; the extreme danger of derailment when entering the water; and the danger, on flat slopes, of obstructions remaining on the rails under water.

There is, however, now being erected at the Hickory Ridge colliery of the Union Coal Co., Shamokin, a permanent water hoist on a 70° slope (Fig. 11), in which it is believed that many of these difficulties have been obviated. The tanks have a capacity of 1,400 gallons each, and are mounted on closed, self-oiling wheels with bronze bushings, and close-fitting bronze shields in the end of the hubs, which fit over bronze collars on the axles. The wheels are made with extra high flanges, and the tank is provided with top and side shoes, as shown, which slide in between permanent guides, extending 20 ft. above the water line, at the foot of the slope, to avoid danger of derailment when striking the water; the pitch being 70° there will be no danger of obstructions remaining on the rails under water.

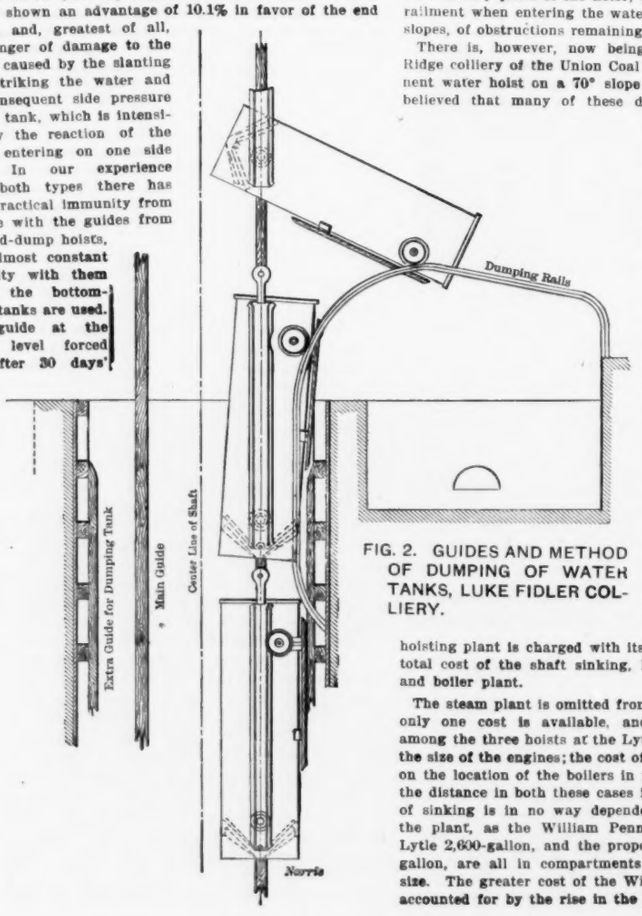


FIG. 2. GUIDES AND METHOD OF DUMPING OF WATER TANKS, LUKE FIDLER COLLIERY.

The cost of construction of only two recent plants is available, in which cost the water-hoisting plant is charged with its proper proportion of the total cost of the shaft sinking, head frames, steam lines and boiler plant.

The steam plant is omitted from the last figures because only one cost is available, and that, from a division among the three hoists at the Lytle shaft, in proportion to the size of the engines; the cost of steam lines is dependent on the location of the boilers in relation to the shaft, and the distance in both these cases is considerable. The cost of sinking is in no way dependent upon the capacity of the plant, as the William Penn 1,440-gallon tanks, the Lytle 2,600-gallon, and the proposed Williamstown 4,400-gallon, are all in compartments of practically the same size. The greater cost of the William Penn plant is fully accounted for by the rise in the price of materials during

	William Penn water hoist.	Lytle water hoist.
Depth of shaft..:	963 ft.	1,500 ft.
Capacity of tanks.	1,440 gals.	2,600 gals.
Size of engines...	32 x 48 ins.	36 x 60 ins.
Size of drums....	Straight 12 ft. diam.	Cone 10 to 16 ft. diam.
Capacity of hoist, 24 hours.....	2,100,000 gals.	3,750,000 gals.
Best record, 24 hrs.	2,291,040 gals.	3,772,600 gals.
Cost:		
Sinking and timbering.....	$20,673.81	$22,641.63
Head frame.....	4,224.13	3,540.58
Water hoist engines, foundations and house.	15,583.64	29,053.17
Tanks and ropes..	2,393.23	3,899.65
Steam line.....	3,726.12	4,951.17
Boiler plant.....	.....	16,091.76
	$46,600.93	$80,777.96
Cost, excl'd'g shaft sinking & steam plant.....	$22,201.00	$37,093.40
Cost per 1,000 gals. daily capacity, excluding shaft and steam plant.	10.57	9.87

the past three years and the decreased efficiency of labor in this region.

The three water hoists on which costs of operation are available are the Luke Fidler, Lytle and William Penn shafts; of these the William Penn was first started, Oct. 30, 1902, to unwater the colliery after the strike, the plant having been finished during the trouble; the Lytle has been in operation for about two years; but, owing to the uncompleted condition of the colliery, its work has been irregular, except in removing the water which accumulated during the strike; while at the old Luke Fidler plant the records are in excellent condition, excepting the steam consumption, which is unavailable.

The Lytle shaft was filled to a depth of 860 ft. during the strike and the water, amounting to 274,083,500 gallons, was hoisted out in 37 days and 4 hours. Besides the regular water hoist, tanks were used in all four coal compartments; the plant then consisting of two pair of 2,600-gallon tanks, with two 36 × 60-in. first-motion engines for each pair; also one pair of 1,500-gallon tanks operated by two 30 × 48-in. Corliss engines; the total water hoisted by each was:

	Gallons hoisted.	Average per day.
Water hoist.....	113,154,600	2,977,753
Large coal hoist.....	106,519,400	2,803,142
Small coal hoist.....	54,409,500	1,431,829
Total	274,083,500	7,212,724

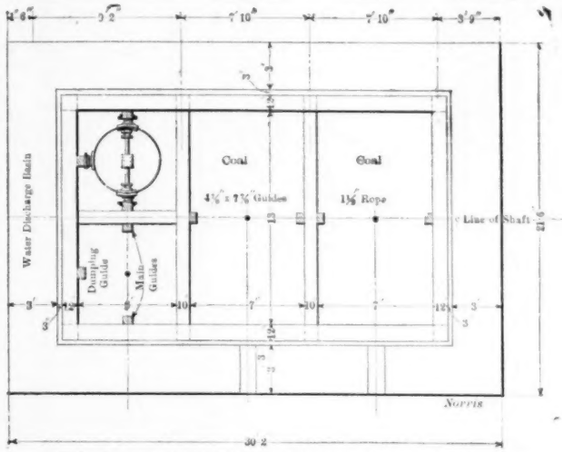
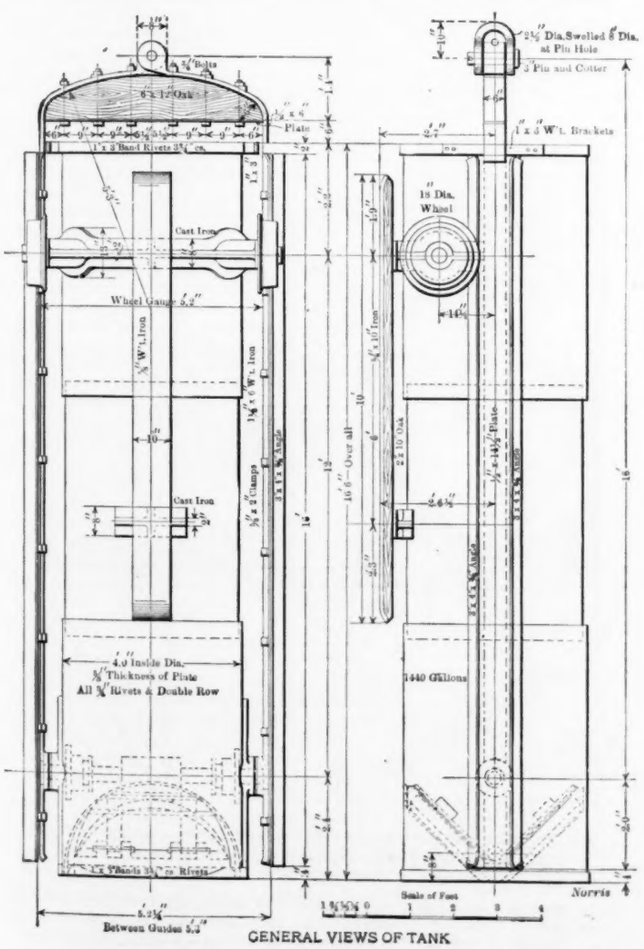


FIG. 3. PLAN SHOWING TIMBER AND GUIDES OF THE WILLIAM PENN SHAFT, SUSQUEHANNA COAL CO.

The hoisting during the month of November was quite regular; 236,906,000 gallons were hoisted from an average depth of 740.6 ft., which is equivalent to 1,463,572,816,468 ft.-lbs. During this time the boiler plant (twelve 150-HP. return tubular boilers and one 500-HP. B. & W. boiler) was devoted exclusively to this hoisting, burned 4,122 tons of coal, and was supplied with 6,206,100 gallons of metered water, which would indicate an average evaporation of 5.55 lbs. per pound of coal. Allowing 15% of the water supplied for use in blowers, condensation and waste, it would be equivalent to about 44,004,000 lbs. of dry steam at the engines, giving an approximate duty of 33,260,000 ft.-lbs. per 1,000 lbs. of dry steam, or 59½ lbs. of steam per actual horse-power hour in water lifted, and 251 lbs. of steam per 1,000 gallons lifted 1,000 ft. This is based on the assumption that the steam used would be proportional to the hoist, which would be, if anything, against the plant.

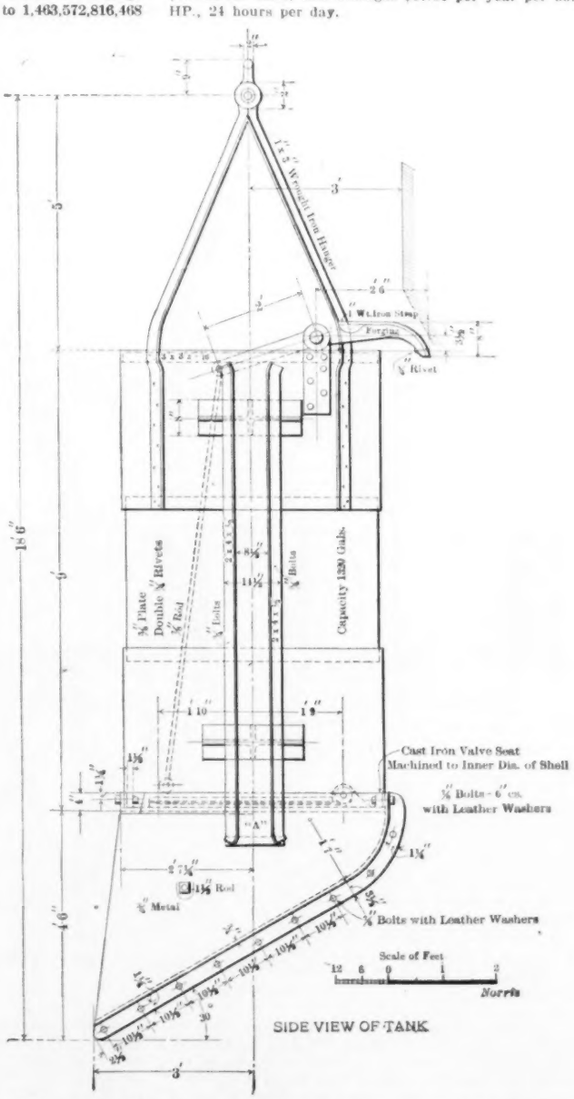
The cost of steam during this month was as follows: Labor, repairs and supplies, $934.62; water, $496.49; 4,122 tons coal at 50 cts. per ton, $2,061.00; total, $3,492.11.

Thus about 44,004,000 lbs. of dry steam delivered at the engines cost $0.794 per 1,000 lbs. (labor, repairs and supplies, $0.0326; fuel, $0.0468); equivalent to $0.0198 per 1,000 gallons hoisted 1,000 ft. vertically, or $0.00238 per 1,000,000 ft.-lbs. in water; $0.00472 per HP.-hour in water; cost of steam only, per year, per boiler HP., 24 hours per day, including labor, supplies and repairs, $8.57; fuel, $12.30; total, $20.87. The cost for generating steam at the collieries of the Lykens Valley Co., figured on the same basis, from data as given in another paper, allowing 15% waste as above, is $0.0811 per 1,000 lbs. dry steam delivered at pumps ($0.0389 for labor, repairs and supplies, and $0.0422 for fuel), and averages $17.04 per year per boiler HP., 24 hours per day.



GENERAL VIEWS OF TANK

FIG. 4. WATER-HOIST DUMPING-TANK OF THE WILLIAM PENN COLLIERY.



SIDE VIEW OF TANK

FIG. 6. EMERGENCY TANK OF THE WILLIAM PENN COLLIERY.

The cost of the steam supplied has been gone into in detail in this place because this plant is the only one at which a single boiler plant has been devoted to water hoisting for a sufficient time to arrive at a fairly accurate estimate of the cost of power, and the figure here obtained, 2 cts. per 1,000 gallons raised 1,000 ft. vertically, will necessarily be used throughout this paper. The cost of hoisting, exclusive of steam, during this month was $1,676.74, or $0.0071 per 1,000 gallons hoisted (including all supplies, labor and repairs).

The new plant of the William Penn No. 2 shaft which was flooded to a depth of 250 ft., hoisted 112,468,080 gallons of water from October 30 to Dec. 5, 1902, inclusive, using the two regular water hoist, 32 × 48-in. engines, both of the 28 × 48-in. engines, the 1,440 gallon end-dump tanks (Fig. 4), and the 1,320-gallon emergency bottom-dump tanks, Fig. 7, the record being:

	Water hoist.	Emergency hoist.	Total.
Tanks hoisted	48,260	32,546	80,815
Hrs. actually worked	805¼	598¼	1,403½
Tanks per hour	59.9	54.4	
Gallons hoisted	69,507,360	42,960,720	112,468,080
Average depth hoisted			727.8 ft.

The total cost, exclusive of steam, was $987.83, or $0.0088 per 1,000 gallons actually hoisted.

The following is the record of the Luke Fidler shaft water hoist 32 × 48-in. engines, with 1,450 gallon tanks, for the three years of regular operation, 1899, 1900 and 1901:

Height of hoist			960 ft.
Tanks hoisted			633,456 "
Average per year			211,152 "
Gallons hoisted			918,501,200
Average per year			306,167,067
Cost of labor	$6,372.00	= $0.00695	per 1000 gals.
Supplies and repairs, including two new ropes, one sheave and one tank	4,087.20	= 0.00445	" " "
Total, exclusive of steam	$10,459.20	$0.0114	" " "
Steam on basis of Lytle figures	17,635.22	0.0192	" " "
Total cost	$28,094.42	$0.0306	" " "

This plant, was, however, only operated at about one-third of its capacity; at full capacity the cost is estimated to average about 2½ cts. per 1,000 gallons for 960 ft vertical.

The operating costs of the three plants just referred to, are summarized in the accompanying table:

COST OF OPERATION OF WATER-HOISTING PLANTS.

Plant	Fidler.	Wm. Penn.	Lytle.
Time	3 years.	37 days.	1 month.
Depth of shaft	960 ft	953 ft.	1,500 ft.
Quantity hoisted	918,501,200	112,468,080	236,906,000
Average height hoisted.	960 ft	727.8 ft.	740.6 ft.
Cost of labor, repairs & supplies per 1,000 gals.	$0.0114	$0.0088	$0.0071
Cost of steam, 1,000 gals.	0.0192	0.0146	0.0148
Total	$0.0306	$0.0234	$0.0219

Estimated cost per 1,000 gallons, 1,000 ft. vertical.

	Fidler.	Wm. Penn.	Lytle.
Labor, supplies and repairs for hoisting	$0.012	$0.009	$0.008
Steam	0.0200	0.0200	0.0200
Total	$0.032	$0.029	$0.028
Total cost per HP.-year, 24 hrs. per day, in water	65.91	60.71	58.97

This is much less, as compared with the average cost of pumping at the collieries of the Lykens Valley Coal Co., of $0.0533 and $0.0380 per 1,000 gallons 1,000 ft. vertical, and $98.11 and $81.47 per HP.-year in water for the years 1901 and 1902, respectively, as shown in my other paper* before this meeting (and which it was estimated could be reduced to about 3 cts. and 2.2 cts. in the respective years by the use of a modern compound condensing pumping plant). In this comparison it should also be considered, however, that the steam cost of hoisting could, if desirable, be proportionately reduced by the use of compound engines, condensing or non-condensing, or even by running the present simple engines as condensing.

Aside from the question of cost, however, there are many very great advantages in hoisting water, particularly from deep shafts: (1) in the simplicity of the construction; (2) having all the operating machinery on the surface, with the resulting low cost of repairs, which are practically confined to tanks and ropes; (3) the almost total absence of slip, which under mining conditions reduces materially, from the quantity calculated from "plunger displacement," the actual quantity of water pumped; (4) the avoidance of underground steam lines, with their large condensation losses, damage to roof and timbering from the heat and exhaust steam, and the danger of fire incident to their use; (5) the almost total freedom from danger of falls or squeezes in the mines; and (6), most of all, because the operating plant cannot be flooded.

These advantages were brought home most forcibly to the anthracite managers this year, when, after a six months' strike, the water-hoist collieries were promptly unwatered, while in our case, at least those where the pumps had been drowned, are still flooded in the lower levels. The history of the Lytle colliery, a notoriously wet one, also furnishes a case in point. Until the accession of the present management, the regular report was, "we are holding the water," and it required several months of unremitting effort moving pumps down the slope, and a tremendous expenditure of money, to clear the colliery of a volume of water barely equal to that removed by the hoisting plant this fall in 37 days, at an expenditure (excluding the value of the coal burned) of $5,918.62.

While the figures presented in this paper are by no means scientifically accurate, the writer has expended no small amount of time and trouble in getting the very best data available, and he believes that the results are as nearly correct as the circumstances will permit, and hopes the figures may be found of value to the profession.

It is also to be noted that, on account of the steam of this constant work on the hoisting engineers, it is the custom to have them work in three shifts of eight hours each.

In conclusion, the writer desires to acknowledge his indebtedness to Messrs. Arthur Kennedy, E. A. Rhoads and Robert Quinn, superintendents, respectively, of the Lytle, William Penn and Luke Fidler collieries, for water-hoist data furnished; to Mr. Hood McKay, superintendent of the Lykens Valley Coal Co., for pumping data; to Mr. R. C. Luther, general superintendent Pennsylvania & Reading Coal & Iron Co., for data of the Reading water hoists, and to Mr. Morris Williams, manager of the Pennsylvania R. R. Coal companies for many valuable points and for permission to publish the detailed costs given.

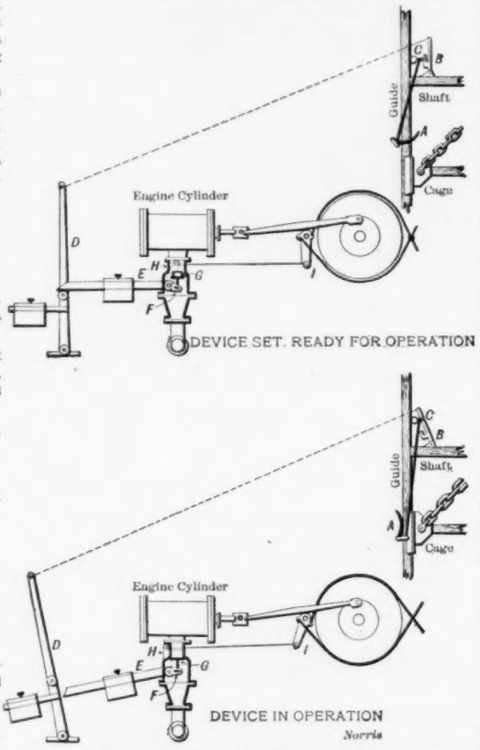


FIG. 5. KOHLBRAKER & WILLIAMS AUTOMATIC OVERWINDING DEVICE FOR HOISTING ENGINES.

CARBONIC ANHYDRIDE REFRIGERATING MACHINERY FOR MARINE USE.

By S. H. Bunnell,* M. E.

The original engineering genius who boldly advocated the use of the high steam pressures of 30 or 40 lbs. was a long step in advance of his contemporaries. Less than a century has passed to the era of ships steaming under pressures above 200 lbs., and refrigerated by gas condensed under a pressure of 700 to 1,000 lbs. Such steam pressures are considered entirely safe, being so common as to be passed without notice, and rarely giving trouble from causes other than defective construction or careless management; while the gas pressures mentioned are involved by the deliberate choice as the refrigerating medium, because of the absolute safety thus afforded, of a certain gas necessarily worked at such pressures.

The process of mechanical refrigeration may be analyzed as the continuous removal of heat from a locality to be cooled by direct transference into

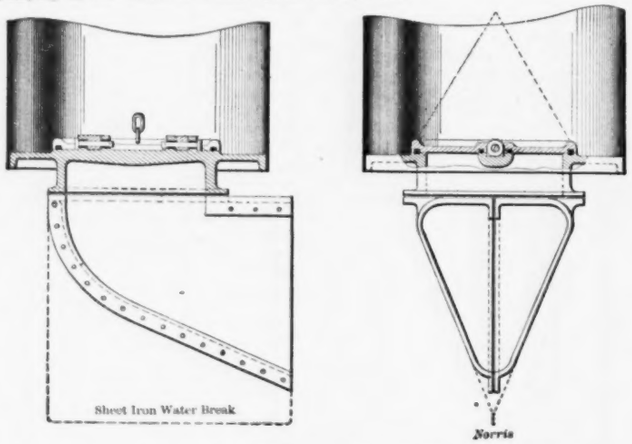


FIG. 7. LYTLE COAL CO.'S BOTTOM DISCHARGE, 5-FT. TANK.

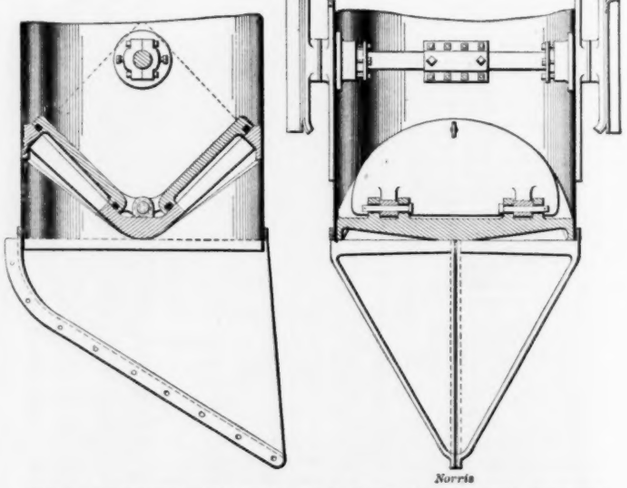


FIG. 8. SUSQUEHANNA COAL CO.'S 5-FT. TANK WITH BOTTOM-DISCHARGE CASTING. THE SAME TANK IS ALSO USED FOR TOP-DISCHARGE WITHOUT THIS CASTING.

*Eng. News, March 12, 1903.

*Vice-President and Manager, The Brown-Cochran Co., Lorain, O.

a carrying medium. This carrying medium is then acted upon mechanically, or otherwise, so as to raise its temperature without addition of heat, in order to make it possible for the heat

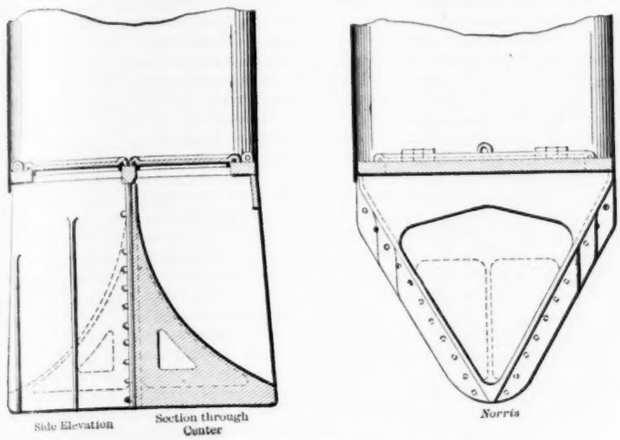


FIG. 9. SUSQUEHANNA COAL CO.'S 5-FT. TANK WITH DOUBLE BOTTOM-DISCHARGE CASTING.

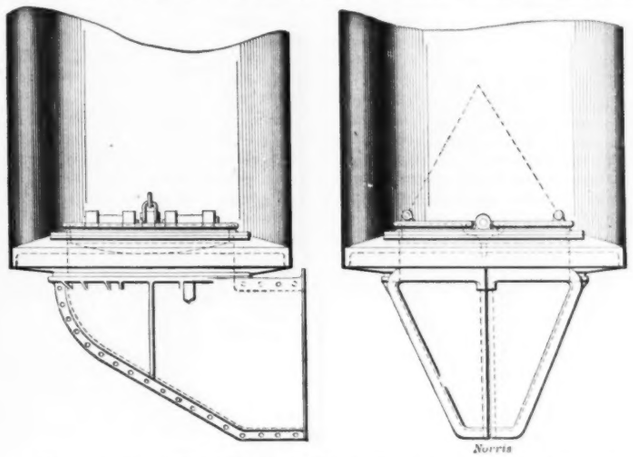


FIG. 10. PHILADELPHIA & READING COAL & IRON COMPANY'S BOTTOM-DISCHARGE 5-FT. 6-IN. TANK.

previously received at a low temperature to be discharged at a temperature naturally obtainable. Evidently the best transmitting medium, which may be called the refrigerant, will be that one capable of carrying the greatest amount of heat per unit of weight or bulk, and of having its temperature raised to that required for discharging with the least expenditure of power. The readily liquefiable gases meet these conditions so satisfactorily that there are but a few special instances of other refrigerants in use. Theory proves that all such gases possess equal efficiency as heat carriers in this process, but in practice it is necessary to make a selection among those liquefiable at the temperature of some cooling medium obtainable in sufficient quantity, such as water. The gases exactly meeting these requirements are few, and each has been given a trial to demonstrate its suitability for refrigeration. Like the steam engine in its early stages, the refrigerating machine commenced its career with low pressures, using such gases as ether, liquefiable at 70° F. under a pressure of 8½ lbs. per sq. in., and by successive steps developed through the use of sulphur dioxide, "Pictet fluid" (a mixture of sulphur dioxide and carbon dioxide liquefiable at moderate pressure), and anhydrous ammonia to the latest type using carbonic anhydride at pressures which would have seemed practically impossible a hundred years ago.

The wide use of anhydrous ammonia as a refrigerant has come about not because this gas is perfectly satisfactory. Coincident with the introduction of the "ice machine," steam was in use at pressures no higher than 60 to 80 lbs. The use under pressures up to 200 lbs. of a gas having a remarkably strong odor and capable of instantly destroying life quite as surely as scalding steam, suggested dangers quite serious enough to enlist the careful attention of designers of such apparatus. The possible safety of a harmless gas under much higher pressures was not considered because no existing methods of construction could cope with gas pressures above 200 lbs. Carbon dioxide, of the common gases the next in sequence to ammonia in liquefying temperature and pressure, liquefies at 70° F. at 890 lbs. per sq. inch., which twenty years ago was considered an impossible pressure except in laboratory experiments.

While the march of progress doubled and trebled steam pressures in the strife for economy of fuel, and simultaneously developed methods and workmanship, making such high pressures safer than the previous low ones, the severe test of experience was developing many objections to the use of ammonia in refrigeration. The heat of compression, if allowed to become too great, causes decomposition of the ammonia and the formation of permanent gases from combination with vapors from overheated lubricating oils, so that the charge of gas must be frequently blown off in part and replaced by fresh ammonia; the chemical affinity of ammonia and copper prevents the use of any brass or bronze alloy, while the enforced use of iron exclusively renders the pipe system certain to corrode and become weakened from the action of cooling water, and especially of salt water; valve stems and light parts of iron tend to rust and stick, and valves to become leaky; the great affinity of ammonia for water makes it impossible to detect any submerged leak till the water is nearly saturated with escaped ammonia; but most serious of all a leakage of ammonia spreads a pungent odor throughout every crevice, destroying provisions and attacking copper and brass articles, and driving the attendants from the vicinity of the leak, or in case of serious accident almost instantly suffocating such men as may not have opportunity to escape.

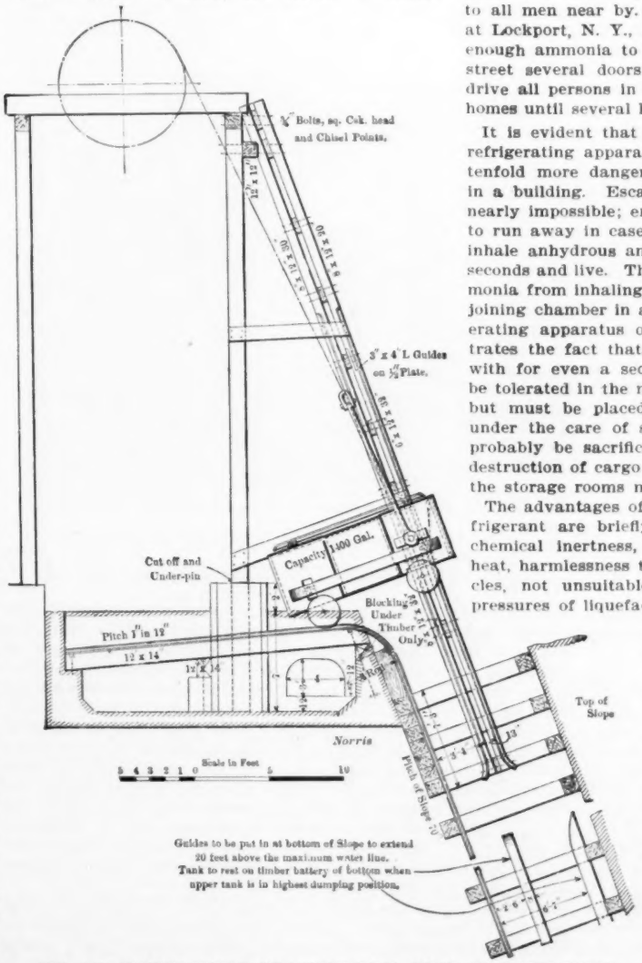

¾" Bolts, sq. Cok. head and Chisel Points.
3" x 4" L Guides on ½" Plate.
Capacity 1400 Gal.
Cut off and Under-pin
Blocking Under Timber Only
Pitch 1" in 12"
12 x 14
Top of Slope
Norris
Scale in Feet
Guides to be put in at bottom of Slope to extend 20 feet above the maximum water line.
Tank to rest on timber battery of bottom when upper tank is in highest dumping position.

FIG. 11. WATER-HOIST OF UNION COAL CO.'S HICKORY RIDGE SLOPE No. 4.

A fire in a cold storage plant is recognized as most dangerous to fight, for the breaking of the smallest ammonia pipe instantly spreads death to all men near by. The collapse of a building at Lockport, N. Y., a few months ago, liberated enough ammonia to kill a horse standing in the street several doors from the building, and to drive all persons in the neighborhood from their homes until several hours afterward.

It is evident that an accident to an ammonia refrigerating apparatus in the hold of a ship is tenfold more dangerous than a similar accident in a building. Escape from the engine room is nearly impossible; engineers of ships do not plan to run away in case of danger, and no man can inhale anhydrous ammonia for more than a few seconds and live. The death of two men by pneumonia from inhaling ammonia escaping in an adjoining chamber in a recent accident to a refrigerating apparatus on a large ocean liner illustrates the fact that the gas is not to be trifled with for even a second. Such machines cannot be tolerated in the main engine room of a vessel, but must be placed in separate compartments, under the care of special men whose lives will probably be sacrificed in case of accident. The destruction of cargo in case ammonia odors reach the storage rooms may cause enormous loss.

The advantages of carbonic anhydride as a refrigerant are briefly: its absolute lack of odor, chemical inertness, great density, high specific heat, harmlessness to animal life and stored articles, not unsuitable temperatures and relative pressures of liquefaction, moderate ratio of compression and expansion, and great efficiency and economy by reason of these various qualities. The first insures that no person shall be discommoded by any escape of gas from the apparatus, nor any damage done by odor or taint clinging to walls or goods in consequence of such escape. The second allows the use of whatever substance or condition is most suitable, as bronze for valves and cylinder parts, copper for condenser tubes, any sort of oil for lubrication, and compression causing any desired degree of heat without the possibility of decomposing or chemically altering gas or oil vapors present in the pipes. The density of the gas and its high specific heat make carbonic anhydride machinery the most compact of all systems, the pipes and valves being very

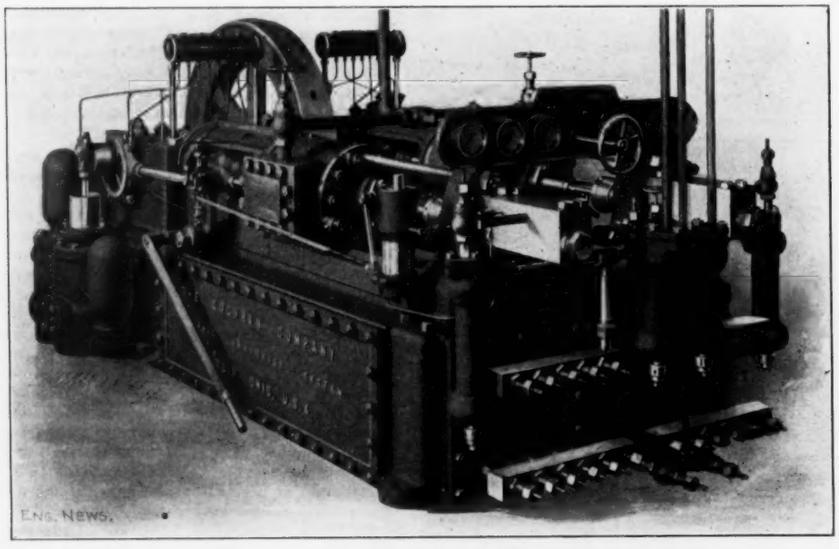
small, and the cylinder volume one-fourth to one-sixth that required for ammonia, for instance. Carbonic anhydride under the name of carbon dioxide is supposed to be a highly poisonous gas, present in ill-ventilated rooms as a constituent of the air exhaled from the lungs in breathing, and to be avoided under all conditions. As a matter of fact, however, it is not carbonic anhydride in a pure state, but mixed with exhaled organic vapors which does the damage; soda water, beer and sparkling wines supply quantities of pure carbonic acid gas right under the noses of the drinkers, and the exhilarating atmosphere of the woods and fields contains much more pure carbon dioxide exhaled by the growing plants than the lifeless air of the city slums. The fact is this gas is harmful in the same way as water; a man submerged in either will die from exclusion of air, but not from poisonous fumes or irreparable damage to lung tissues, while the rapid diffusion of gases makes it absolutely impossible in practice to get a sufficient proportion of carbonic acid gas in an engine room to affect the health or comfort of persons present, even in the event of the escape of the entire charge of a machine. In case of fire in a warehouse, carbonic anhydride escaping could not cause an explosion or drive away firemen, as is too often the case with ammonia, but being in itself a fire extinguisher would assist to some extent in checking the flames.

The liquefaction of carbonic acid gas occurs at a temperature of 70° F. under a pressure of 61 atmospheres; at 75°, 64 atmospheres; at 80°, 68½ atmospheres, and at 86°, 74 atmospheres, above which temperature the gas is believed to be not liquefiable at any pressure. These pressures are not at all dangerous or impracticable, as the use of over 1,500 carbonic anhydride plants on shipboard and perhaps 1,000 on land to-day ought to conclusively prove. Compressed air at 2,000 lbs. is common enough, and liquid carbonic acid in cylinders at pressures due to ordinary temperatures is sold and used everywhere for bottling liquors and raising beer. A 2-inch return pipe will carry enough gas for 100 to 150 tons of refrigeration per 24 hours, so that the small size and consequent strength of the apparatus is apparent. Certainly the work must be well done, but in these days ordinarily competent and reliable men, given proper fittings, are quite capable of putting up a tight and durable job of piping to hold a thousand pounds pressure without leakage. As for the tremendous loss of efficiency supposed to be inevitable when using condensing water at 80° or over because carbonic acid gas cannot liquefy at a temperature over 86°, it is probable that the phenomenon of latent heat absorption follows closely that of liquefaction, and that as the gas passes without demarcation into the liquid state, its capacity for absorption of latent heat may fall off only gradually, being considerable even at as high a temperature as 100°.

The relation of condensing and evaporating pressures of carbonic anhydride is, however, the most important factor in the demonstrated efficiency of the refrigerating apparatus. Taking the severest conditions usually met in practice, refrigeration at zero Fahrenheit and condensation at 80°, carbonic anhydride would be evaporated at about 18 and condensed at 70 atmospheres, a compression ratio of less than 4 to 1; while anhydrous ammonia must be evaporated at about 1 atmosphere and compressed to 16 atmospheres, at a ratio 16 to 1, so great that it would be considered intolerably inefficient for single-stage air compression. The designers of ammonia apparatus have acknowledged the serious liability of loss of efficiency from this cause by clinging to single-acting cylinders, attempting to run pistons to contact with heads of cylinders at end of stroke (making some provision to allow the head to yield in case of faulty adjustment), providing oil injection to fill clearances (with consequent evaporation and atomization of oil and its thorough mixture with ammonia, part going to coat inside walls of pipes and part forming objectionable permanent gases in the system) and finally by some futile attempts at two-stage compression. At best, and even when ammonia vapor is allowed to be drawn into the cylinder, the heat developed by such high ratios of compression plays an important part in destroying the ammonia by chemical dissociation. As the carbonic anhydride machine is ready to do business year in and year out under the very hardest conditions with the compression ratio of the common air compressor delivering air at 45 lbs. gage, it is hardly necessary to suggest that there is a good deal of room for loss of efficiency in latent heat capacity (and from the specific heat of the liquid, which is a technical matter of minor importance) before the economy of the apparatus suffers in comparison with that of ammonia apparatus at the enormous single-stage compression ratio of 16 to 1.

The question of theoretical efficiencies has, after all, little value in comparison with practical results; but practical tests giving higher results than are theoretically possible are subject to grave suspicion. The writings of scientists on this subject have failed to take into account the practical losses from leakage of pistons, expansion in clearance and other circumstances, and engineers have therefore been disposed to discredit the careful and exhaustive experiments made by a committee of the Danish Agricultural Society in 1898, in which an anhydrous ammonia, a sulphurous acid and a carbonic anhydride machine were given an elaborate test, later repeated with other ammonia and carbonic anhydride machines. The report of these tests was translated into English and published in 1899 by "Ice and Cold Storage," of London. Both sets of trials showed marked superiority for the carbonic machine; the final results being .96 HP. per ton of refrigeration for the carbonic against about 1.40 HP. for the ammonia, refrigeration being at 37° F. and condenser water at 77°, and 1.21 HP. and 1.70 HP. respectively with condensing water at 86°. These tests were made with machines of two to three tons capacity in dairy service, hence the choosing of 37° for the refrigerating temperature instead of a lower and more representative temperature; but it is safe to say that the carbonic machine would have much to gain in comparison with the ammonia apparatus by an increase of the difference between condenser and refrigerator temperatures, which would very greatly raise the ratio of compression of the ammonia, while only slightly affecting that of the other gas.

The only apparent rival of the carbonic anhydride machine is the dense-air system, but as this has no point of superiority except the cheapness of its refrigerant—and liquid carbonic acid is certainly cheap enough—while a complete air-expansion engine must form part of the machine, adding weight and complication, and the efficiency falls far short of the theoretical due to the mechanical losses, the carbonic anhydride apparatus seems to have a strong claim for the first place among refrigerating machines for use on sea or land.



DUPLEX HORIZONTAL COMPRESSOR FOR CARBONIC ANHYDRIDE REFRIGERATING APPARATUS.
Built by the Brown-Cochran Co., Lorain, Ohio.

Until recently there has been no carbonic anhydride refrigerating machine manufactured in the United States, though foreign-built ships are very generally equipped with such machines constructed by German or English shops. The two new steamships of the Red Star Line of the International Mercantile Marine Co., built at Cramp's yards in Philadelphia, are equipped with carbonic anhydride refrigerating apparatus made by the Cochran Co., now the Brown-Cochran Co., of Lorain, O., these machines being shown by the illustrations. These compressors are of duplex type, consisting of two pairs of tandem steam and compressing cylinders, whose pistons are connected to a common crank shaft carrying a flywheel at its center. This design is equivalent to a duplicate plant, as one side of the machine could be operated even in case of the complete disabling of one cylinder. The crank shaft is of forged steel and has bearings on each side of each crank. On its outer ends are carried the eccentrics operating the balanced slide valves of the steam cylinders, and at one end is a crank which drives a differential-plunger circulating pump supplying sea water to the condensers. The whole machine is supported by a hollow box bed-plate of cast iron containing the condenser coils, which are of seamless copper tubes divided into ten separate sections, each with its own independent set of shut-off valves, while a partition divides the box into two equal parts, thus affording the advantage of two separate condensers, each so subdivided that a leak in a pipe would require the cutting off of only one-tenth of the condensing surface.

The compressing cylinders are of forged steel, machined from the solid. Piston rods are of nickel-steel, threaded into steam piston tail rods to allow of adjusting clearance or disconnecting to apply new stuffing-box leathers. The valves are of nickel-steel, of identical form for both suction and discharge, and each is covered by a separate threaded cap. Any valve can thus be removed or examined in a moment. Stop valves are of bronze, except those of the condensing coils, which are of steel, carried in steel headers, in which all seats are machined from the solid. All packing is by metallic gaskets closely secured by tongue and groove joints.

The compressor piston rods are packed by cup leathers, arranged so as to form a chamber in which an oil pressure greater in constant ratio than the condenser pressure of the carbonic anhydride is maintained by pumps. The oil pumps are

driven by rods from the main valve motion rockers, and are of forged steel with steel valves working on bronze seats. An accumulator cylinder forms part of each pump, providing an oil supply for some hours in case the pump should fail to operate for a time owing to dirt in the oil or other slight derangement. The principal journals are lubricated from central oil boxes provided with syphon feeds and piped to the various oil holes.

The general design is massive, yet without involving weight unnecessary for the durability and reliability of the machine. The duplex feature renders the apparatus practically beyond the possibility of disabling accident. The feature of copper condensing coils in connection with the use of sea water for condensing is evidently very valuable, as such coils are indestructible, while the iron pipes necessary with other refrigerants rapidly corrode to dangerous weakness. The provision of proper by-passes and valves renders it easy to pump out any coil or portion of the apparatus.

Much study has been given to making the apparatus absolutely unbreakable, and to supplying extra parts for every possible emergency. Half the machine may be disconnected in a few minutes by simply removing a connecting rod cap; and the other side may then be run for hours at twice its rated speed if necessary.

These machines have been in service nearly a year and with unqualified success. With the smaller outfits installed by the Brown-Cochran Co. on well-known yachts, the testimony of practical service on shipboard is all in favor of the carbonic anhydride machine for marine refrigeration.

A SPRAYING DEVICE FOR COOLING AND AERATING WATER.

The cost of water is an important item in many manufacturing processes, and considerable effort and expense is warranted in order to conserve the supply. This is particularly the case where the water has to be purchased from the city or town supply, and it is likely to be the case where an independent supply is had by pumping from deep wells or neighboring streams. In all cases where water is used for dissipating heat, as in power plants, refrigerating plants, breweries, etc., the

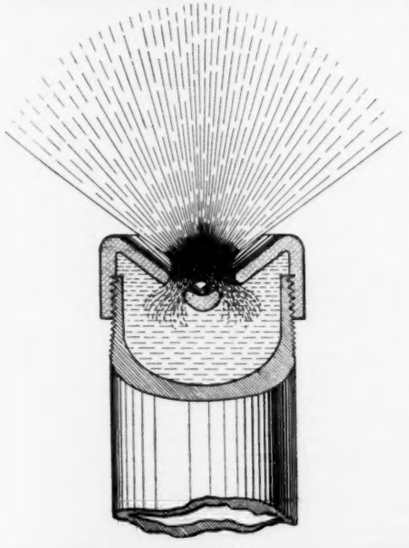


Fig. 1. Sectional Elevation of Simplex Spraying Nozzle.

E. A. Uehling, M. Am. Soc. M. E,, New York City, Inventor.

cooling of the water is a necessary requisite to its conservation. There are a number of ways of performing this cooling operation which are familiar to our readers. One of the most recent of these is a spraying system using a special form of spraying nozzle invented by Mr. E. A. Uehling, M. Am. Soc. M. E., of New York city. This nozzle has been named the "Simplex" because of its simple form, as is shown by Fig. 1.

The novelty in this nozzle consists in the manner in which the spray is produced, and the feature of advantage claimed for it is that it spreads the water uniformly in a perfect spray, the fineness of which depends on the pressure. It is stated

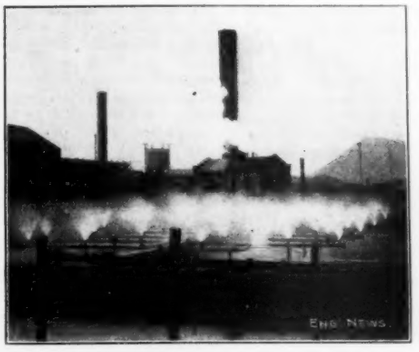


Fig. 2. View of Spraying System for Cooling Water from Blast Furnace Tuyeres, Sir Bernard Samuelson & Co., Ltd., Middlesborough, England.

that with a head of from 10 ft. to 12 ft. each nozzle will spread 1,000 gallons of water per hour evenly over a circular area from 12 ft. to 16 ft. in diameter. With a head of from 35 ft. to 40 ft. about double this quantity of water will be thrown into an almost perfect mist. The nozzle is so designed that it will not clog with anything that will pass a ¼-in. mesh strainer.

For cooling or aerating water in large quantities the nozzles are arranged as shown by Fig. 2, which is a view of a plant cooling back 50,000 gallons of tuyere water per hour at the works of Sir Bernard Samuelson & Co., Ltd., at Middlesborough, England. The water simply flows by gravity from the troughs round the furnaces to the nozzles, no pumping being required. The temperature of the pond varies from 74° to 80° F.; before the nozzles were put in it was 110° F.; although the pond was then three times its present area. The head on the nozzle is only 9 ft. In writing us concerning his device Mr. Uehling says:

> While apparently the largest field of application would seem to be that of cooling back water, there are many other applications to which it will lend itself with equal efficiency, and in some of which it may be destined to fill a long felt want. We may mention, for instance: Aerial oxidation of chemical solutions, oxygenization of drinking water, distribution of liquids over large filtering areas, cooling pig iron and other materials, and wetting down the sand preparatory to molding up, etc., etc.

We are indebted to Mr. Uehling for the information from which this description has been prepared.

NOTES ON ACCIDENTS DUE TO COMBUSTION WITHIN AIR COMPRESSORS.*

By Albert R. Ledoux, M. Am. Inst. M. E.†

With the improvements in design and efficiency of machinery the element of danger in its use is becoming less, but it is a question whether the strain involved in operating modern plants is not increasing somewhat the danger of accident due to human fallibility.

I propose to describe a somewhat uncommon casualty resulting from a not infrequent incident in the use of air compressors, and partly due to lack of judgment of the engineer and lack of care in operation. It is not necessary to state the location of the mine in which the accident occurred nor the makers of the compressor, and the object of this brief paper is more to draw out suggestions from members more familiar than am I with the practical handling of mining machinery, than to point a moral.

The compressor in question was a three-drill machine of standard make. At the time of the accident it was furnishing air to a single drill working in an upraise from a well-ventilated tunnel, and giving ventilation to a winze below the tunnel where two men were hand-drilling. The compressor also furnished power to a small hoist in the winze, but the hoist was only operated occasionally, and never while the drills were working. The drills were located about 1,200 ft. from the compressor. The engineer testified that he never had been short of air, and that there had been no complaints that the machine was inefficient. The engineer testified, further, that the water used in cooling the air-cylinder had never become greatly heated, but that he used a mixture of good cylinder oil and of a lighter grade known as "Atlantic Red." The valve of the compressor was set to blow off at 80 lbs. He was eating his luncheon in the boiler room when he heard a "crack like a pistol," and, going into the engine room, found water spurting out of the jacket about two feet from the end of the compressor; he tightened the jacket and stopped the leak, and found that the jacket was perfectly cool. He next noticed that "grease began to fry on the pipe and receiver."

He next saw that the air pipe had become red hot, the heat extending to a point where the pipe went through a wooden partition, setting fire to it. Then he noticed that the pressure was going down "just as quick as if someone had opened a valve outside," which, in fact, is what happened. He stopped the engine, but, getting the signal for more air, started up again. It is well to note at this point that the intake of the compressor was in the engine room, the temperature of which usually stood at 115° F.

Let us now see what occurred in the mine. What happened at the bottom of the winze cannot be better told than in the testimony of one of the miners at the coroner's inquest:

> I was turning a hole and my partner was striking the drill; he says, "We ain't got much air here this morning; I will ring for some more air." He rang, started to strike again, and struck two or three blows; straightened up and took a couple of breaths of air, and started in to strike again, and then quit. I had been joshing him, and says, "You ain't as tough as you used to be." I stood up, picked up a pick, struck two or three blows, and felt that the air was bad. Just then the air stopped, and the hoist tender hollered to us that there was no air and we had better come up. I looked around and seen my partner standing in the corner. He was all trembling, and I caught him as he fell over.

These two men were gotten up by heroic work on the part of comrades, and their lives were saved. But not so fortunate were the men in the upraise. There were four of them here, and when they felt the air getting bad they opened the valve full—of course, only increasing the difficulty. They were experienced miners, and at first could not understand what was the matter with them, because their candles continued to burn as usual. This was due, undoubtedly, to the fact that they were working in an upraise, and that the heavy carbonic-acid gas sank, and perhaps to the fact that carbonic oxide may have been generated through incomplete combustion or the reduction of the carbonic acid, first formed by the glowing carbon in the pipe.

Two men were killed and four others barely escaped with their lives, as a result of the combustion of the oil, deposited carbon and organic dust accumulated in the compressor, receiver and pipe. Explosions of air compressors due to this cause have been frequent, and lives have been lost thereby; and what is known as the "flaming" of compressors or cylinders is an everyday experience, and in some cases the rupture of the air pipes, but, so far as I can ascertain, without the serious consequences described in the present case.

I shall leave to those better qualified than I the discussion of the best means of preventing such catastrophes. Among those which suggest themselves are the taking in of the air from a point where its temperature is as low as possible; the introduction of auxiliary coolers, the use of as heavy oil as possible, yet never in excess; the cleaning out of cylinders, receivers and pipes; and especially a warning to the engineer to be very sure, when he receives a signal for more air, that the actual shutting down of the compressor may not be more essential. In this case, had he shut down, it is probable that no lives would have been lost, for with the stopping of the air the miners would have at once returned to the tunnel level.

*A paper read at the Albany meeting of the American Institute of Mining Engineers.

†Consulting Engineer and Assayer, 99 John St., New York city.

A REMINISCENCE OF EARLY RAILROADING.*

When the State of Pennsylvania opened the Philadelphia & Columbia Ry., the theory was that the state should furnish the roadway and that any one that pleased could furnish his own vehicle and motive power and use the railway whenever he pleased, by paying the state tolls for its use, just as the turnpikes of the day were used. But it was soon discovered that a certain character of vehicle was necessary and that rules and regulations as to times and manner of using the railways were absolutely necessary in order to their successful operation. The ordinary shippers found it too expensive to furnish the necessary plant, and that they could get this transportation done by large and well-equipped shippers much more cheaply than they could do it themselves, so that in practice the business drifted into the hands of a few individuals and companies, who did this service for the many. The railway as constructed was intended for the horse as motive power, though the locomotive was being introduced as an experiment shortly after the railway was completed.

The following, among the rules and regulations adopted

*Extract from a paper by Antes Snyder, read before the Engineers' Society of Western Pennsylvania.

by the canal commission for the regulation of the railway may be of interest:

Section 92. No car shall carry a greater load than 3 tons on the Columbia & Philadelphia Ry., nor more than 3½ tons on the Portage Ry., nor shall any burden car travel at a greater speed than five miles per hour, unless the car body shall be supported on good steel springs.

Section 108. It shall be the duty of the conductors of cars moving with less speed upon railways, upon notice by ringing a bell, blowing a horn, or otherwise of the approach of a locomotive engine or other cars moving in the same direction at a greater speed, to proceed with all possible dispatch to the first switch in the course of their passage and pass off said track until said locomotive engine or other cars moving at greater speed can pass by. The conductors of the slower cars are directed to open and close the switches so as to leave them in proper order. Any person who shall refuse or neglect to comply with the provisions of this regulation shall, for every offense, forfeit and pay the sum of ten dollars.

FAST RUNS ON THE CHICAGO & NORTHWESTERN RY.

During the last week in March some high speed records were made by the eastbound Chicago Special of the Chicago & Northwestern Ry. in the run across Iowa between Council Bluffs and Clinton. The average speeds for a distacce of 202 miles were 50 to 56 miles an hour, while stretches of four to five miles were made at speeds of 75, 82 and 96 miles per hour. The trains were made up of five cars, and weigned 250 and 305 tons on different days. They were hauled by single engines of the Atlantic type of the following dimensions:

Driving wheels	6 ft. 2 ins.
Weight on drivers	91,000 lbs.
" " truck	33,000 "
" " trailing wheels	34,000 "
Total weight of engine	158,000 "
Weight of tender	110,800 "
Cylinders	20 × 26 ins.
Boiler pressure	200 lbs.
Coal capacity of tender	10 tons
Water capacity of tender	5,500 galls.
Available tractive force	20,800

For the above particulars and for the tabulated results given below we are indebted to Mr. R. H Aishton, General Superintendent of the Chicago & Northwestern Ry. While excellent runs were made on March 24 and 25, these are only representative of the regular service, but on March 26 there was some very rapid running for long distances, as will be seen by the following record:

RECORD OF THE "CHICAGO SPECIAL," CHICAGO AND NORTHWESTERN RAILWAY.

	March 24	March 25	March 26
Cars in train	5	5	5
Weight of train	250 tons	250 tons	305 tons
Council Bluffs to Boone, Ia.: 148.1 miles.			
Engine No.	D. 1024	D. 1024	D. 1024
Left Council Bluffs	5.55 a.m.	4.37 a.m.	5.25 a.m.
Arr. Boone	9.13 a.m.	7.53 a.m.	8.45 a.m.
Distance, miles	148.1	148.1	148.1
No. of stops	5	5	5
Elapsed time	3 hrs. 18 mins.	3 hrs. 16 mins.	3 hrs. 18 mins.
Running time	3 hrs. 1 min.	2 hrs. 59 mins.	3 hrs. 1 min.
Average speed, miles per hour	49.15	49.70	49.15
Bursts of speed, miles per hour:			
Glidden to Ralston	70.00		
Scranton to Jefferson		67.50	
Denison to Vail			65.00
Boone to Clinton, Ia.: 202.3 miles.			
Engine No.	D. 1082	D. 1083	D. 1086
Left Boone	9.35 a.m.	8.00 a.m.	8.50 a.m.
Arr. Clinton	2.03 p.m.	12.42 p.m.	12.43 p.m.
Distance, miles	202.3	202.3	202.3
No. of stops	10	9	9
Elapsed time	4 hrs. 28 mins.	4 hrs. 42 mins.	3 hrs. 53 mins.
Running time	4 hrs. 0 min.	4 hrs. 17 mins.	3 hrs. 36 mins.
Average speed, miles per hour	50.2	47.1	56
Bursts of speed, miles per hour:			
Low Moor to Camanche, 5.0 miles		75	75
Stanwood to Clarence, 5.0 "	75		75
Watkins to Norway, 4.1 "	82		82
Tama to Le Point, 4.8 "	72	72	96
Lamville to Marshalltown	73	73	73

ESSENTIALS NECESSARY FOR SUCCESSFUL PRACTICE IN BRIDGE ENGINEERING.*

By J. E. Greiner,† M. Am. Soc. C. E.

The education obtained in a university or technical school does not in itself make an engineer. The first few years after graduation should be considered as a post-graduate course, in which the student is both master and pupil. The youth endeavoring to establish a professional standing must apply his spare time to the study of the progress constantly being made and to the engineering problems which are so freely discussed in technical societies and in technical journals, in order that sooner or later, when he is brought face to face with a proposition of somewhat unusual character, he will be prepared to grasp the situation and accomplish results promptly and effectively.

In my experience with young graduates I have found that it is the exception, rather than the rule, for them to continue their studies after they have received their diplomas, or until forced to do so by coming in contact with a problem which they cannot solve readily. At the present time a young graduate has no trouble to obtain a position in some branch of engineering. If he has an inclination towards structural work, he will probably obtain employment with some bridge company as a draftsman. This means the preparation of detail drawings for the shop, in the execution of which he is not required to use much of his mathematical knowledge. Unless he is an exception to the rule, he will plod along, doing in a more or less satisfactory manner the detail work laid out for him, without troubling himself to search for the whys and wherefores. He is paid for making drawings at a fixed rate per hour, and is satisfied to let it go at that, rather than use his own time in familiarizing himself with the engineering part of the work. No man should be satisfied to have another determine for him the number of rivets required in a connection or splice, the sizes of pins, the thickness of bearing or pin plates, the proper packing of eye-bars. He should determine these things for himself, not so much as a check on the work of the chief draftsman as to prepare himself to meet future conditions.

Detailing is, of course, a very important part of the post-graduate education of an engineer, but when one accepts employment as a draftsman, he should not be content with the mere routine work of preparing shop drawings. He should take advantage of every opportunity to learn something.

Neither should he permit himself to become rusty in the studies to which he has already devoted so much time. Rustiness in mathematics may be excusable in a man who has met and passed through the period of personal application and whose work has become extended to executive duties, but it is not excusable for a man to forget what he has learned before he has had a chance to apply it. The successful engineer may be considered a "has been," so far as his ability as a mathematician is considered, without any reflection whatever on his ability as an engineer. On the other hand, the young man who permits himself to forget his mathematics before he has had an opportunity to apply them, and who, when the time arrives, finds himself deficient through [illegible], will in all probability never be referred to even as a "has-been," because he is likely to become a failure as an engineer and had better open a grocery store.

The duties of mill and shop inspection give opportunities for a kind of education which cannot be obtained from books or lectures. The mill is the place to learn the practical working of metals, and the shop is the place to learn how the bridge is fabricated.

Inspection of work under way in the field has also educational advantages, for here the young man will see how the expert erectors rig up and handle the different parts which, when placed together, will form a complete bridge or structure. These erectors are working for contractors who are not at work for the mere love of it, but for the money which they expect to make out of it. They, therefore, take advantage of everything which will enable them to save a dollar, and that foreman who can put up a structure for the least cost and who avoids accident, is the most valuable to his employers. He is usually a very rough stone, but at the same time he is a general and a captain.

Although the young man may obtain employment immediately after his graduation, and although he may be called an assistant engineer, he is not yet an engineer. He is merely in training or is continuing his studies in a practical field, for although the work that he does may have a pecuniary value to his employer, he is only a student or apprentice. The beginning of an engineer's education is what he learns while at the university. His employment as a draftsman, shop or mill inspector, field inspector, should be considered by him as a continuance of his education, and not as practicing his profession. This being the case, in all probability the young man will ask, "When would you consider that I am practicing?" In answer to this question I will say that a man does not begin practicing engineering until he is qualified to design and superintend work and until he has actually taken charge of engineering work.

When a young engineer obtains his first position he usually starts out with vim and ambition and displays a strong desire to learn. He is interested in the work in hand, even if it is tracing details or inspecting material, because it is new to him. After a year or two the novelty wears off and we find some of the men becoming tired of the routine, losing interest because they believe they are fitted for greater things, and are deserving of more pay. The greater things and increased pay being slow in materializing, they reach that stage where they begin to be slow in starting work in the morning and quick in leaving it at night. They become careless in their work, and failing to check up a calculation, there results a misfit and a reprimand. Again, in a thoughtless moment, they write down 9 ft. while thinking of 6 ft.; result, another misfit and a warning. Again, they become indifferent to the instructions of their chief; result, discharge on account of unsatisfactory service, unless, as is frequently the case, they find employment elsewhere before they are actually dismissed. Perhaps they have secured a little more salary in their new position, because it happened that the new employer needed men at once, and was willing to pay well for temporary work. When the work is finished, or perhaps before, they have secured employment elsewhere. They have developed into tramp

FIG. 1. RIO GRANDE BRIDGE, EL PASO & SOUTHWESTERN R. R., NEAR EL PASO, TEXAS.

H. J. Simmons, Chief Engineer, El Paso & Southwestern R. R.; Missouri Valley Bridge & Iron Works, Leavenworth, Kan., Contractors for Substructure; Phoenix Bridge Co., Phoenixville, Pa., Contractors for Superstructure.

*Extracts from a lecture delivered March 27 before the students of Cornell University.

†Engineer Bridges and Buildings, B. & O. R. R. Co.

draftsmen, and will never pass beyond. They will collect a lot of testimonials and drift from place to place, always ready to change for a dollar or two extra pay. There are quite a number of tramp draftsmen and engineers, as can be readily ascertained by inserting an advertisement in a technical journal. These men usually get employment during prosperous times, as at present, but they have a struggle during periods of depression.

There are other classes of men who manage to advance beyond the ranks of draftsmen or inspectors, not because they are specially fitted for the higher position, but rather because they happen to be the most desirable men immediately available for the salary allowed. A type of one of these classes will be constantly in a rush and apparently overburdened with the multitude of his duties.. He works hard and faithfully, is very conscientious, but is so particular about small things that he frequently blunders in those which are important. He will worry over his calculation and have the figure in the fourth decimal place absolutely correct, but will be erratic in the whole numbers. Men of this class are great in the little things, but incapable of dealing with the larger problems which all successful engineers must encounter.

A type of another class which arrives at an elevation slightly above that of draftsman or inspector and then remains stagnant is he who has a good, quiet, manly bearing, which impresses those with whom he comes in contact and which often leads to his chief giving him a trial when the opportunity is open. Unfortunately, when the trial comes, he is found lacking in decision or ingenuity and continually brings to his chief for settlement all those matters which admit of several solutions. He has been placed in charge for the purpose of deciding these details, but he has not kept pace with the times, has not read and digested the articles published in the technical papers or discussed in engineering societies, has relied upon his text-books and his narrow experience for ideas, and fails, not because he has not the foundation, but because he has been too indolent to continue his studies and to train his faculty of observation.

It now remains to state the character of those who are or will be successful. Of course, there are men who have success thrust upon them, and who could not stand without support. These will not be considered. The real engineer who has mounted step by step until his work, his character and his ability are universally recognized by his associates, needs no support from influential friends. He stands on his merits. He will be found to have a forceful and decisive way of giving orders or directing work, which inspires confidence in those with whom he is dealing and which establishes loyalty among his subordinates. He is always fair, reasonable and just in his dealings with contractors and brother officers. He is above flattery and his loyalty to the interests which he serves and his integrity are matters which no one thinks of questioning. He has been a student and a close observer all his life, and while he has made some mistakes, he has invariably profited by them in learning what to avoid.

When he became a designing engineer, he knew what was practical and effective construction, what was cheap and good, or cheap and bad, what was expensive and ineffective and what was expensive, but necessary.

Thus, step by step, he has advanced through the various departments, always a student, always open to improvement, always ready to consider suggestions, until finally, as chief of a large corporation or a consulting engineer of great reputation, he stands as a model, possessing all the essentials necessary for successful practice.

THE RIO GRANDE BRIDGE OF THE EL PASO & SOUTHWESTERN R. R., NEAR EL PASO, TEX.

By R. A. Thompson.*

The recently completed line of the El Paso & Southwestern R. R., between El Paso, Tex., and Bisbee, Ariz., crosses the Rio Grande River about 4.5 miles west of the city of El Paso, just above the Mexico-New Mexico boundary line and a short distance below the site proposed for the great international irrigation dam, a bill for the construction of which is now before Congress. Its bridge is also only a few hundred feet below the present bridge of the Southern Pacific Ry. across the Rio Grande River.

FIG. 2. VIEW OF RIO GRANDE BRIDGE, SHOWING STEEL VIADUCT TOWERS AND ABUTMENT.

The size and cost of the bridge is unusual in the Southwest and it is, therefore, of more than ordinary interest in this territory. Its construction involved some interesting features and was carried on under conditions somewhat out of the ordinary. It is made up, Fig. 1, of five parallel chord deck spans, each 181 ft. long, resting on solid concrete piers, and of eight 70-ft. deck plate girder spans, supported by six steel towers, each of which carries a 35-ft. deck plate girder. The steel towers rest on small concrete piers. The total length of the steel structure is 1,692 ft. 6 ins. Its maximum height above the river bed is 86 ft. and it is 73 ft. above the high water mark.

The main spans have a depth between chord centers of 30 ft., with 16 ft. between truss centers, and each is made up of seven panels, 25 ft. 10 3-16 ins. in length. The bridge is designed to carry a live load consisting of two consolidation locomotives, with 40,000 lbs. on each driver, followed by a train load of 4,000 lbs. per lin. ft. The dead load is estimated at 2,300 lbs. and the wind pressure at 600 lbs. per lin. ft. respectively. The entire weight of the steel structure is 1,311 tons.

The bodies of the large concrete piers have an average height of 49 ft. and are 28 ft. 2½ ins. × 14 ft. 5½ ins. at the bottom. They rest on concrete bases 6 × 20 × 34 ft., which in turn rest on piling at depths varying from 9 ft. to 23 ft. below the natural surface. The piers have a batter of ¾-in. per 12 ins. in height, giving a dimension under the coping of 8 ft. 4 ins. × 22 ft. 4 ins. The coping is 18 ins. deep and projects 6 ins. out all around the top of the pier. A projecting V is built on the up-stream side of each pier 10 ft. long, which is carried up to a height of 4 ft. above high water. The concrete bases rest on piles, spaced 3½ ft. between centers, and driven to an average depth of 26 ft. The piles project up into the concrete base 18 ins., and over them is laid a No. 4, 6-in. mesh, expanded metal covering. The large piers contain on the average 702 cu. yds. of concrete each and 5,797 cu. yds. of concrete is used in the entire structure.

The erection of each of the main spans required from four to five days after the false work had been put in, and about the same time was consumed in removing the false work and erecting it for the next span. The first girder was put in place on Aug. 27, 1902, and the last span completed on Oct. 4, 1902. The floor system or deck of the approaches is made of 8-in. × 8-in. × 12-ft. Texas pine ties, spaced 6 ins., dapped on the girders, and surmounted by an 8 × 8-in. guard rail laid over each girder and dapped about 1 in. onto the ties. This deck is anchored to the steel girders by means of hook bolts through the guard rails in every third tie. The main spans have a deck made of 8-in. × 8-in. × 18-ft. pine ties, spaced 6 ins. apart, and surmounted by a double line of guard rails on each side, which are secured by hook bolts. The track consists of 75-lb. steel rails with an inner guard rail spaced 8 ins. from each track rail. The entire bridge is built on an 0.8% gradient rising to the west. Figs. 2 and 3 show the spans under erection.

The river bed at this point is composed almost entirely of drift material, and as no floods of any magnitude occurred during the construction the work progressed under the most favorable circumstances. The extraordinary height and dimension of the bridge was necessary, not particularly because of the natural difficulties which the river offered, but on account of the heavy and difficult construction encountered in the hills of New Mexico, immediately to the west, which involved the driving of a tunnel 1,000 ft. long.

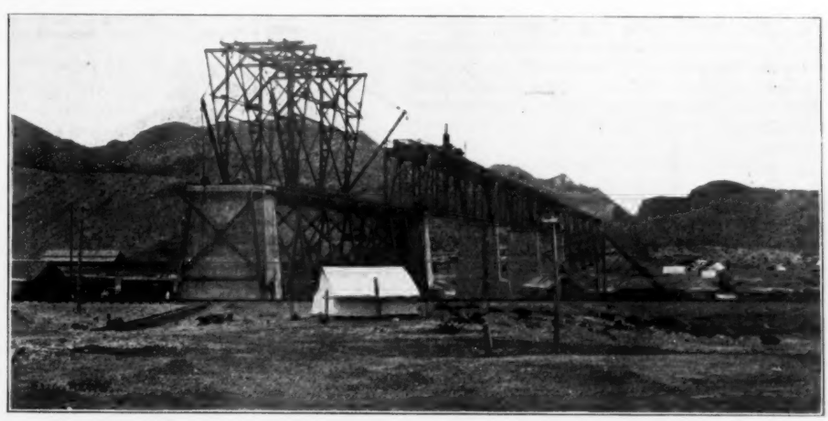


FIG. 3. VIEW OF RIO GRANDE BRIDGE, SHOWING FALSE WORKS AND TRAVELER FOR ERECTING TRUSS SPANS.

Work began on the bridge in April, 1902. The substructure was completed in August, 1902, and the superstructure in October, 1902. The substructure was contracted for by the Missouri Valley Bridge & Iron Works, of Leavenworth, Kan., and the superstructure was erected by the Phoenix Bridge Co., of Phoenixville, Pa. The bridge was constructed under the supervision and direction of Mr. H. J. Simmons, Chief Engineer of the El Paso & Southwestern R. R., and Mr. F. B Wilson, Assistant Engineer.

*Chief Engineer Railroad Commission of Texas, Austin, Texas.

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

One of the most common fallacies with respect to the floods of great rivers is that they are chiefly due to the removal of the forests from the lands whence the river's tributaries flow and that the proper remedy for disastrous floods is to again cover these lands with a forest growth. Many have seen the flow of small streams greatly affected by the clearing of their drainage basins, and reasoning from the less to the greater it is natural to conclude that the same causes govern the alternation of floods and low water in large rivers.

The current number of "Arboriculture" sets forth anew this old fallacy, and the editor concludes a discussion of several pages with an appeal for "a systematic re-afforestation of the mountain regions . . . . in, order that these surplus waters may be made to serve our country instead of mastering it."

We heartily favor the extension of forest culture and forest preservation, but every claim that such work can solve the problem of flood prevention does harm, since it creates opposition to plans for treating the broad subject of river regulation on sound engineering lines.

Briefly stated, the fact is that forests do not increase rainfall, and while they distribute the run-off from a given area over a somewhat longer period than would be occupied if the same area were cleared land, this conservation of the flow is chiefly of importance in increasing the low water flow and not in diminishing flood heights. Further, this effect is of practical importance only on small streams. In the case of large rivers it is too trivial to be noticeable. This is not mere theory, but actual fact, established by multitudes of observations. The floods of the Ohio and the Mississippi appear from historical records to have been as great when the forests on their headwaters were practically untouched by the axe as they are at the present day. It is true that the recorded flood heights of the lower Mississippi have increased with each great flood for several years; but this is due to the fact that the river is now confined to its channel by levees instead of being permitted to spread over the entire width of the bottom lands.

In New York, recently, a movement has been started to establish a scientific system of river regulation under control of the state. In the report of the State Water Storage and Flood Prevention Commission,* made up of eminent engineers, it was stated that no work which the state could undertake would be productive of such enormous benefits. Yet the movement in the present legislature to continue the work of the commission has met with great opposition from men whose chief plea has been that the proper remedy for flood prevention was restoration of the forests. It is fortunate, indeed, that this is not the case, for if it were, the floods in our water courses would have to continue their annual devastation unchecked. It would be out of the question to take great areas of land from productive agriculture and devote it to forestry.

The fact is that the work of river regulation, while it is a field of which the public knows nothing, is no new field to the engineer. In the thickly settled countries of Europe, where every scrap of land has a value, it was long ago found necessary to protect the lands along the water courses from injury by floods or erosion, and this not merely through towns and cities, but along the entire course of the stream. In this country only a small beginning has been made in this direction; but it is certain to become an important field of work for the engineer.

A necessary precedent to such work, however, is the passage of proper legislation to place the matter of riparian rights on a just and equitable basis and enable improvements to be carried out in a broad and permanent manner and not piecemeal, as has hitherto been the practice. As the New York Water Storage Commission said in its report:

> All experience, here and abroad, has demonstrated that no improvement of a river by dyking, straightening or enlarging its channel can safely be undertaken except by treating the river as a whole from source to mouth.

In this work of river regulation and land reclamation, two great obstacles stand in the way: our cumbersome and antiquated laws respecting water rights and interstate relations thereto and our still more cumbersome and antiquated titles to lands and their transfer.

Public opinion must be educated to demand radical legislation in remedy of these obstacles or some of the greatest and most important works in water conservation and land reclamation will be impossible.

We give up considerable space in this issue to two of the most important contributions on the design of naval water-tube boilers that have appeared in a long time. The first of these gives the results of five years' practical experience with water-tube boilers in the "Marietta," and the second summarizes the results of the notable series of tests which have been in progress for nearly two years with a new boiler known as the Hohenstein. This boiler has given such remarkable results that it seems bound to attract the attention of naval authorities the world over.

We wish here to call attention to one particular feature in the design of this boiler, which we are inclined to believe accounts in a large degree for its success, and that is the free circulation that is afforded. It will be seen by referring to the views of the boiler which are published on another page that there is no restricted section to obstruct the flow of the circulating water from the time it enters the downflow tubes until it returns to the steam drum.

This is the more important because the matter of circulation in steam boilers has been a subject over which many engineers have stumbled. Nearly ten years ago the late John J. Hogan of Brooklyn originated the theory that bubbles of steam rising in water do not tend to produce circulation, and presented some ingenious but fallacious arguments on behalf of the theory. The matter attracted little attention in this country, but in England where the problems in connection with naval boiler design were then arousing great interest this theory was then taken up and vigorously espoused by "The Engineer." In this way a good many engineers and boiler designers were led astray on this important matter, and more or less harm was done through neglect of the matter of circulation in boiler construction. For this reason a boiler designed on the sound idea of securing a free and unrestricted circulation is of particular interest.

*Eng. News, Jan. 29.

The Milwaukee, Wis., "News," in commenting on the passage of the 1,000-ton barge canal bill by the New York legislature, remarks:

> Though the proposed improvement will serve to relieve the freight situation, the Northwest will not remain content until a deep waterway from the lakes to the ocean is secured. It is an improvement that should be undertaken by the general government—an improvement that so far as the middle West and Northwest are concerned is of greater importance than the Isthmian canal. If the federal government does not undertake to secure a deep waterway connecting the lakes and the ocean, the Canadian government is certain to enter upon the enterprise. It is an improvement that cannot much longer be neglected with safety to national interests.

One of the special advantages usually claimed for concrete work is that it can be safely built by unskilled labor, but in view of some recent accidents which have occurred it appears well to point out that this principle is not of universal application. For concrete in large masses such as abutments, foundations, retaining walls, etc., there is no doubt that unskilled labor can be safely and successfully employed, under proper supervision. But for certain other classes of work, girders and floors in concrete buildings, it appears that some degree of skilled labor should be employed, or that at least the entire work should be under strict and constant supervision by skilled foremen, architects or engineers. In the carpentry work for forms and falsework especially, there is frequent evidence that the weight of the mass to be supported and the hydrostatic pressure of very wet concrete in columns are not realized by the men who are entrusted with the construction of this part of the work. When concrete has once thoroughly set it will stand very hard service and even overload or abuse, but it should be very strongly impressed upon the men engaged in concrete construction that the wet mass is simply a dead weight to be supported, having absolutely no supporting power in itself. If steel bars, rods, etc., are used, these simply add to the weight of the wet mass. The fall of a concrete floor at Chicago, noted in our issue of Dec. 4, seems to have been due entirely to an ignorant man blindly following out instructions which were probably extremely indefinite. He was told to go in and knock out some of the shoring, and he proceeded to knock out every bent, until the unsppported concrete gave way, and in its fall broke through other completed concrete work below.

Another accident which is said to be due to failure of falsework is recorded elsewhere in this issue. In another case which came under our personal observation a laborer was found knocking away some of the struts and braces under a green concrete floor, simply because (as he told the superintendent when discovered) a carpenter told him to get some lumber. When informed that he stood a good chance of killing himself and other men in the work, as well as of wrecking the building, he simply became surly and appeared to think that the superintendent was making a fuss about nothing. The same applies to the concreting gang. The men usually employed for this class of work simply dump the concrete into the forms without discretion, frequently being left without observation by even a foreman for a considerable time. This is especially serious at the junctions of concrete columns and girders. We have heard of instances where forms for girders were filled before the form at the junction with the column was complete, the men simply putting a piece of plank at the end of the form for the girder to make a stop-off and prevent the concrete from running out. If the column is built immediately and the block pulled out there may be little harm done, but there is the liability that the plank may be forgotten, or the concrete of the girder allowed to set before the concrete for

the column is deposited. In either of these cases the girder becomes a cantilever, being partially or entirely separated from the column, instead of forming a homogeneous mass with it. There is no doubt that a great deal of concrete work is built by men who are really not competent to undertake it, and that much more work is done without sufficiently strict and continuous expert supervision to ensure the best and safest results. In view of the enormous increase in the use of concrete, and in the variety of purposes for which it is used, it is well for engineers to bear these facts in mind.

In alluding to the recent growth of the American Institute of Electrical Engineers last week we remarked that the American Society of Mechanical Engineers and the American Society of Civil Engineers each had "something over 2,500 members on their rolls." Since our last issue the 1903 catalogue of the latter society has appeared and reference to this and to the new catalogue of the Mechanical Engineers shows that these figures are a little above the mark for the Mechanical Engineers, and considerably below the mark for the older society. The total in all grades in the Civil Engineers is 2,725. In the Mechanical Engineers it is 2,419.

Many of our readers may remember the spectacular manner in which a few years ago an invention known as the ball nozzle was exploited in New York city. A large store on Broadway was leased for its exhibition and the popular journals gave (?) large space to its description. Yet nobody ever hears of the "ball nozzle" nowadays.

That invention was designed, however, to meet a real need, viz.: a nozzle for the delivery of a stream of water in a fine spray and not in a solid jet. The ordinary resource of the engineer when in the design of an apparatus he has to produce a fine spray of water is to use orifices of small size; and these are well known to give constant trouble by clogging and rust.

We illustrate in this issue the best solution of this problem in engineering that we have ever seen, a nozzle which by the action of the water on itself delivers a broad spray, and which contains neither small orifices, moving parts or obstructions likely to cause clogging or to be soon worn out by the action of the water. We are inclined to think that this simple device will have a much longer life and much broader field of usefulness than fell to the lot of the much-advertised ball nozzle.

MACADAM AS A PAVEMENT FOUNDATION.

Whether or not macadam is preferable to concrete as a foundation for pavements is a question raised by a correspondent, who sends us the following letter:

Would you kindly advise me in your columns which is the better, paving on concrete or paving on macadam, and the relative merits of each?

We may preface our answer to this question by saying that comparatively few pavements have been laid upon macadam as a base. There is, however, every reason to believe that precedent is the chief reason for the preference shown concrete in the past. In the city of Buffalo there are many miles of asphalt pavements laid on concrete, much of which is like the waves of the sea. One street is exceptionally free from such irregularities, and there, we are informed, the asphalt was laid on a macadam foundation.

Macadam carefully laid and compacted by a 10-ton roller will certainly uphold as heavy loads as an equal thickness of concrete, and it possesses the advantage, due to the use of the heavy roller, that the subsoil is more thoroughly consolidated than where concrete is laid. Moreover the surface of well-made macadam has fewer pronounced irregularities than has ordinary concrete, which is a very important consideration where asphalt is to be the wearing coat. Under the summer heat asphalt softens, and some experiments made by a member of the editorial staff of this journal indicate that, when in this soft state, wagon wheels tend to roll and push the plastic asphalt in such a way as to make its surface parallel with all the irregularities of the surface of the concrete beneath. Concrete has a greater transverse strength than macadam, to bridge over depressions; but the better consolidation of the sub-grade effected in the process of making a macadam foundation in itself offsets this greater transverse strength of concrete, and insures a more even surface of the pavement after traffic comes upon it.

Where there are car tracks in a street, macadam placed between the rails can be rolled only with difficulty; concrete seems to be the preferable base between the rails for this reason.

The inspection of macadam construction is far more easily carried out than that of concrete; moreover there are no cement tests to be made. Another point, not unworthy of consideration in these days of labor troubles, is the very small force required to lay 50 cu. yds. of macadam per day as compared with the force required to lay an equal amount of concrete. It takes about 18 men to lay 50 cu. yds. in 10 hours, whereas three men dumping and spreading stone, a sprinkling cart and a steam roller will do the same work on macadam. In fact, where fire hydrants are close together the sprinkling cart may be replaced by a man with a hose.

Turning now to the comparative first cost of the two materials, it may be noted that in some localities gravel is cheap while broken stone is expensive, due to the absence of outcropping ledge rock. In such places a gravel concrete may be cheaper than macadam of equal thickness. Again, in some of the smaller cities it would be difficult to get the steam roller which is a necessity for making a good macadam foundation, and if the job is a small one it may not pay to rent a roller and pay transportation charges both ways.

These, however, are exceptional conditions. In most localities macadam can be laid for much less cost than concrete; and, if the preceding discussion is well founded, it has been used far less than its low cost and its efficiency warrant.

THE DEPTH OF FREEZING AND THE LOSS OF COLD BY CONDUCTION IN THE FREEZING PROCESS OF TUNNELING.

In connection with the plans proposed for building the Pennsylvania R. R. tunnels under the Hudson and East rivers at New York city by the freezing process, a question which at once arises as to the practicability of the method and which would seem to be the crucial one, is: To what distance will the material freeze from the surface where the cooling effect is applied, in a given time, and what will be the loss of cold by conduction into the soil beyond the frozen mass? There seems to be but few data in technical literature which bear directly upon this point, although the freezing process of mine shaft sinking has been frequently adopted abroad, and the following information based on records made at a mining shaft sunk at Iron Mountain, Michigan, and which has been given to us by Mr. Charles Sooysmith, M. Am. Soc. C. E., should be of general interest to engineers.

In sinking the Iron Mountain shaft pipes 8 ins. in diameter were sunk in a circle 29 ft. in diameter through water-bearing soil to a depth of about 90 ft. below the water surface. The strata passed through consisted chiefly of coarse and fine sand, with occasional layers of boulders. The pipes were closed at the bottom and chloride of calcium brine cooled by an ice machine to about 5° F. was circulated in them. In 39 days freezing had taken place to a distance of 4 ft. 5 ins. outside of the circle of pipes and to a somewhat greater distance inside the circle. In 70 days the distance frozen inwardly from the circle was 11 ft.; the distance frozen outwardly was not determined at this time. During the latter part of the work the ice machine was run only to maintain the frozen wall which was already of unnecessary thickness. When the work was completed measurements taken 20 ft. from the surface gave a distance frozen outward from the circle of pipes of 8 ft. 4 ins. There was, however, reason to believe that further down the distance frozen outward was at least 12 ft. For some of the rooms of a cold storage plant, it is now common to circulate the brine at a temperature of — 15° F., and Mr. Sooysmith states that the general principle of conductivity indicates that if at Iron Mountain the brine had been circulated at this temperature below zero instead of at five degrees above zero, these frozen distances for the same period of time would have been 12 ft. and 16 ft., respectively. Finally, it may be noted that it was not until 50 days after the completion of the Iron Mountain shaft, that the frozen wall thawed sufficiently at its thinnest place, which was probably under the ends of the pipes, to admit any water through it, although attempts were made to hasten thawing by letting steam into the pipes as the shaft was needed for the drainage of the valley.

Some of the excavated frozen material from the Iron Mountain shaft was experimented with and the number of thermal units that had been abstracted from it in cooling and freezing was ascertained, and with these data the total number of thermal units which would have been required to be abstracted to solidify the entire mass, which had been frozen on two different dates, was calculated. Continuous observations were also made of the volume of brine pumped and the change in its temperature by passing through the ground pipes, and from these the number of thermal units actually taken from the earth during the same periods was calculated. These two amounts were so nearly the same as to indicate that the amount of cold lost by conduction into the unfrozen mass outside the wall was small. Mr. Sooysmith thinks this is as might be expected, for, the conductivity of frozen earth being greater than for unfrozen earth (the conductivity of ice is about four times that of water), the cold is more readily transmitted through the earth already frozen to the outer limit of the frozen material where it meets a barrier of slower conductivity and is utilized in taking up the latent heat of the water contained in the earth.

From the experiments and experience noted above Mr. Sooysmith reasons as follows: It needs but a small proportion of the cold to cool the earth outside of the frozen mass. For example, suppose the material to be frozen to a distance of 5 ft. outside of the excavation necessary for a full-size railway tunnel, and that the material outside the frozen mass were cooled from a temperature of 32° F. at the limit of frozen material to 1° F. below the normal temperature at a distance of 8 ft. away, this outside cooling would have required but about 12% of the total capacity. The interior of the frozen mass is cooled far below the freezing point and so acts as a reservoir of cold, as it were, and if the refrigerating plant were stopped, this mass would continue for some time to send out cold to advance the limit of frozen material, which is in the condition of ice in an ice house, and months would elapse before it would thaw. In explanation of the large amount of cold and freezing effect that can be delivered by a pipe in contact with earth through which pipe brine is circulated, it should be borne in mind that a cubic foot of chloride of calcium brine will for each degree of temperature carry about 60 thermal units, which is, for example, about 300 times as much as for a cubic foot of air at atmospheric pressure.

Outside of the observations above mentioned, the tests made by physicists on the absolute conductivity of water, ice and the materials from which soils are composed, are recorded in the text books. It appears that the absolute conductivity of frozen soil is about 20. That is, 20 British thermal units will pass through a body of frozen soil 1 ft. square and 1 in. thick in one hour with a difference in temperature of 1° F. Using this constant in the formula for conductivity as given by Rankine and others and applying to a case similar to those shafts at which observations have been made, the result agrees fairly well with the observations recorded.

The theoretical and practical deductions are such as to permit fairly accurate forecasts of the freezing that can be accomplished under given conditions, and with any given arrangement of appliances for the distribution and application of the cold.

THE CENTRAL RAND GOLD MINING COMPANIES will expend $250,000,000 during the next decade in development work, according to a recent report of the Engineers of the Chamber of Mines. There are now 6,000 stamps at work and 12,000 more will be dropping before ten more years have passed, according to this report.

LETTERS TO THE EDITOR.

Some Additional Data on Concrete-Steel Chimneys.

Sir: The article on concrete-steel chimneys, appearing in your issue of April 2, is full of interesting material. My notes give for a chimney at the plant of the Singer Manufacturing Co., at Elizabethport, N. J., the following:

The Singer chimney is a straight chimney 125 ft. high, with a 9-ft. flue. It weighs 250 tons, the load on the base being 9½ tons to the square foot; 20 lbs. per foot was allowed for wind pressure in designing the chimney. What is known by concrete men as "wet" concrete was used. By a wet mixture is meant one which quakes slightly when rammed, by dry mixture is meant one which requires repeated ramming to bring water to the surface. The concrete was mixed according to the following proportions: 1 part American Portland cement, 3 parts sand, 5 parts broken Hudson River limestone (stone broken to pass through a ¾-in. ring unscreened). All of the concrete was machine mixed.

This is an additional chimney to your list. The above was taken, I think, from some of the building-trades papers. The chimneys at South Bend, Ill., are 130 ft. high, with 6-ft. flues. Engineering News of Sept. 19, 1901, contains a communication from me regarding a concrete chimney at Bellinzona, Switzerland, but it is not a concrete-steel structure. Yours very truly,

W. W. Christie.

Paterson Savings Building, Paterson, N. J.,
April 4, 1903.

Instrumental Work in the Watchung Tunnel.

Sir: The east and west headings of the Watchung tunnel met Jan. 26, 1903, the east heading having been driven 3,852 ft. and the west heading 3,548 ft. The difference in alinement was 0.04 ft. and in grade 0.014 ft. This tunnel was cut through rock without shafts and is part of the new water supply for Jersey City, now in course of construction by the Jersey City Water Supply Co., Mr. Edlow W. Harrison, M. Am. Soc. C. E., Chief Engineer.

In producing the center line a Berger transit was used. Line was given and taken with a plumb bob, behind which an electric lamp fitted with a bright reflector was held. The lamps used were of 50 c. p. and were attached to about 30 ft. of corded wire, terminating in a plug which could be screwed into a socket holding a 16-c. p. lamp, which latter are used in the tunnel.

For leveling a Young level was used, level readings being taken with a mining rod having a horizontal slit cut through the center of the target, behind which an electric light was held. The writer had charge of the work for the Jersey City Water Supply Co., and the instrument work was done by Mr. Frederick Pansing. The contractors for the tunnel were the Hudson County Contracting Co., of Jersey City, and James P. McDonald, of New York. Mr. John Buele was superintendent for the contractors, and the fact that no casualties occurred reflects the greatest credit on his management.

Charles W. Bance, Asst. Engr. J. C. W. S. Co.
158 Ellison St., Paterson, N. J., Jan. 30, 1903.

Bottom Chord Loads in Fink Roof Trusses.

Sir: Having had occasion recently to determine the stresses in a Fink roof truss carrying loads on the bottom chord in addition to the regular roof loads, the following graphical solution was developed and is here given, with the hope that it may be of interest to those having similar problems to solve.

The loads on the accompanying diagram are from an assumed load of 60 lbs. per sq. ft. (horizontal area) for the top chord, and 150 lbs. per sq. ft. for the bottom chord; the truss has a span of 60 ft. and a rise of 15 ft., and trusses are spaced 16 ft. c. to c.

The load line is laid off in the usual manner (here for one-half the truss); d n represents half the apex load, plus half the load at the center of the bottom chord. The stress

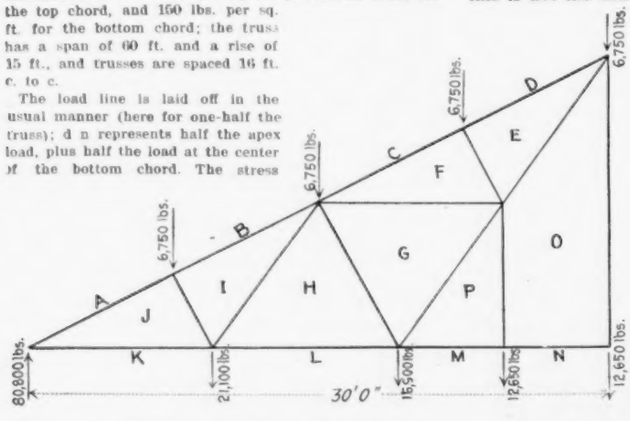


diagram is constructed as usual to determine the stresses in A J, B I, J I, I H, H L and J K. To determine the stresses in the other members of the truss, proceed as follows:

From m and n on the load line draw parallel to the bottom chord, the indefinite lines m t and n s. Through c and d draw the indefinite lines c u and d v parallel, respectively to C F and D E, and from h draw h w parallel to H G.

Through h draw a parallel line to B I intersecting n s at x; draw xz, which line represents the stress in the hanger O P, but whose position is as yet unknown. Through x and z draw lines parallel to G P or O E and draw x y parallel to H G; draw y z′ and z′ y′. Then the triangle h y′ z′ is similar to h r z″, and has one side (h z′) equal to the true intercept on h w cut by the lines representing the stresses in P G and O E. From y′ draw a line parallel to hw to intersect the center line between c u and d v at y″, and through y″ draw lines parallel to F G and O E these intersect c u and d v at f and e, respectively, and h w at g, thus giving the stresses in C F, D E, E F, and F G. The line e y″ intersects n s at o, giving the stress in O N and determining the true position of the line representing the stress in O P. The line through g parallel to G P closes on p, completing the diagram.

If the hanger P O is omitted the line representing the stress in P M will occupy a position midway between the lines p m and o n on the stress diagram, the triangle x y z vanishes and therefore y″ moves up to the line h w (becoming coincident with g) and g p is the closing line as before. Yours truly, W. H. Dunham.

266 Lexington Ave., Buffalo, N. Y., Feb. 10, 1903.

(The artifice employed by our correspondent determines the stress component in F G due to the load P O; the line y′ z′ represents this stress-component, and must be added to the line f y″, and the component in F G due to load C D, in order to give the total stress F G, represented by the line f g. The same result is reached probably a little more rapidly by the construction shown by the dotted lines o′ p′, o′ e′, f′ e′, and the line f′ g′ drawn parallel to F G, so as to intersect p′ g′ drawn parallel to P G. Then the three points f′, e′ and g′ have the same relative positions as the points f, e and g, whose position is as yet unknown. Since f lies on c u, e on d v, and g on h w, the line g′ g parallel to d v gives the true point g. —Ed.)

The Settlement of the Buffalo Breakwater.

Sir: In Engineering News of March 19, p. 250, it is stated that during storms portions of the Buffalo breakwater settled or sank 10 to 14 ft. into the clay, and shows typical cross-sections before and after the damage. But the second section above the depth of 30 ft. is as large as the first. Is the error in the drawings or in attributing the deformation to a yielding of the foundation?

D. E. Hughes.

San Diego, Cal., March 26, 1903.

(The drawings referred to were furnished us by the engineer in charge of the work. We presume they were made with the aid of the knowledge gained by soundings, supplemented with investigations by a diver. The statement that the structure settled 10 to 14 ft. into the clay was also quoted from information furnished us by the engineer.

If the coping stones are as represented in Fig. 2, still in close contact with each other, across the line of the breakwater, it seems certain that the clay under the breakwater must have yielded to some extent, although it must be admitted that this is not the manner in which failure would be expected to occur. If the clay under the stone mound is soft enough for such a movement, we do not see why it did not first yield under the side thrust due to the coping stones laid on the slopes of the superstructure. Even earth of considerable firmness will yield under a moderate amount of side thrust, while it takes very soft earth indeed to move like a liquid under a vertical load, particularly under a structure having so broad a base (over 140 ft.) as the Buffalo breakwater.

In a personal letter our correspondent who writes the above letter for publication states that in his experience settlements of rock mound breakwaters have been generally due to the use of too steep slopes or stone of too small size. It may be questioned whether the fact that the Buffalo breakwater settlement took place under the harbor side with its slope of 1 on 7, while the lake side with a very much flatter slope was left intact, does not indicate that the failure was due to the side thrust of the coping on the harbor side.—Ed.)

Is the Force of an Explosion Equal in Every Direction When the Explosive is Not Confined?

Sir: In your issue of March 26, p. 279, you answer in a positive manner the question asked by "H. H. E., Golden, Colo.," relative to dynamite and the tamping necessary. It is the opinion of the writer that the action of dynamite is not so simple as set forth in your answer. A short time ago, an inquiry emanating from a body of miners reached me. The sense of their question was embodied in "H. H. E.'s" inquiry, and arose from an argument relative to the direction of the resulting action of the detonated dynamite. After considerable research, many conflicting opinions and impressions were discovered. A report reached me this morning, which I shall verify if possible, that a certain mining company in this state uses dynamite without tamping. I should like very much to have the question answered:

Does the explosion of a powder (dynamite in particular) exert an equal force in all directions if free?

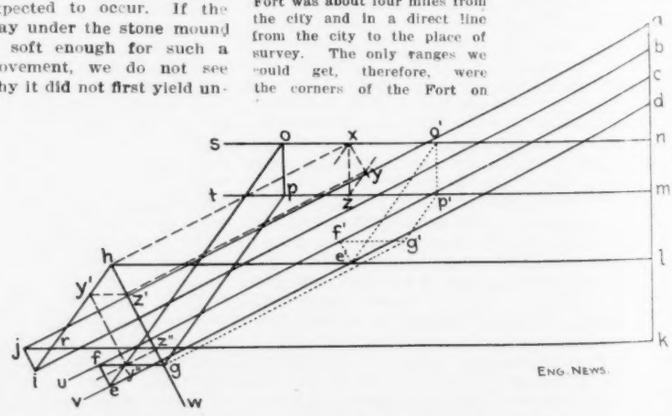
Very truly yours, Claude W. L. Elkins.

Dept. of Civil and Mining Engineering, Colorado School of Mines, Golden, Colo., March 31, 1903.

(In our answer to the query of "H. H. E., Golden, Colo.," two statements were made, both without qualification: (1) Tamping over dynamite is essential in securing the best results with the least powder; (2) The explosive force of free dynamite is exerted equally in all directions. Statement (1) is based not only upon the experience of members of the editorial staff of this journal, but upon the authority of every text-book writer on blasting. There is not a single record to the contrary of which we have knowledge. Statement (2) is an answer to a somewhat academic question, since dynamite is not commercially exploded "free." We should be pleased to receive any evidence tending to show that the gases generated by explosion do not expand equally in all directions with equal velocity when "free."—Ed.)

A Method of Making and Plotting Hydrographic Surveys.

Sir: I have read with interest Mr. Bacon's account of his method of making and plotting surveys on the Cumberland Sound improvement work (Eng. News, March 26). The same method with a few slight changes has been used on the Charleston work for many years. At Charleston, instead of using only ranges and one angle in the boat, we used our transitman placed on Fort Sumter and read angles from the boat. The reasons for the observer at Fort Sumter were twofold. The critical portion of our work was about four miles from Fort Sumter and the Fort was about four miles from the city and in a direct line from the city to the place of survey. The only ranges we could get, therefore, were the corners of the Fort on some point in the city. These ranges did well enough for steering by to sound, but were not accurate enough to plot the soundings by. An observer was therefore placed on Fort Sumter. At certain intervals the sextant observer would read his angle and at the same instant drop a signal and the transitman would catch the angle, each man recording the exact time of the signal in his note-book.



As there was an automatic tide gage at Fort Sumter, and the sounding party stopped there to see that it was in

sounding order, on the way down to the work there was no time lost in putting an observer out there. This is an important consideration where you can only sound from one to two hours at high or low water. This was about the only method of doing the work there, as most of the soundings were over three miles from land in one direction and about four in the other, and too much time would have been lost each time in placing and going for transitmen. In the office we had a large map of the jetties and harbor with sets of circles through the same two points inscribed upon it in the same manner that Mr. Bacon describes. We had sets of circles through different objects for different parts of the works, so that we would always have a good intersection with the transitman at Fort Sumter. Some years four surveys would be made of the important part of the work and we would plot the surveys by placing a piece of tracing cloth over the map with the circles upon it. We would place a heavy weight at the station the transitman occupied. This weight had a needle and with an eye driven in that could be centered over the station and in this eye was fastened a black silk thread. The plotter would set this thread on the angle read out of the transitman's note-book by means of a natural tangent protractor on the edge of the map, and then mark the point where it intersected the sextant angle. In this way two men could plot very rapidly. I entered the Charleston office in February, 1891, and this method had been used before that time. I don't know by whom it was introduced there. It is, of course, only an elaboration of the method that is described roughly in Johnson's "Surveying." It is, as Mr. Bacon says, a very fine method where many surveys are to be made over the same area, but would be too much trouble and take too much time in preparing for it for a single survey,

Very truly yours,
Walter M. Smith, Assoc. M. Am. Soc. C. E.
U. S. Engineer Office, Portland, Me., March 30, 1903.

Laying Submerged Concrete-Jacketed Steel Pipe Across the Hackensack River—Additions and Corrections.

Sir: In your issue of March 12, 1903, there appeared an article on the submerged pipes across the Passaic and Hackensack rivers on the aqueduct line of the new Jersey City water supply, which contains a number of erroneous and misleading statements, and fails entirely in noting the radical new features in design and methods of construction in which these pipes differ from any heretofore laid.

As the design and methods pursued in this part of the work on the new water supply contract were of great interest, and were subjected to especial study by the engineering staff of the company, and, as examples, are likely to be adopted in many particulars and probably improved upon by other engineers confronted with a similar problem in the future, it seems proper that any account of it published in a paper of the broad circulation of the Engineering News, should be correct.

The pipes in question were not designed or laid with any reference to the 16-in. pipes drawn across the Passaic River (at Belleville—Ed.) in 1895. The only particular in which the two cases are alike is that both cross rivers, and both were built up on the shore and projected or drawn across. In this last they are similar to numerous pipes laid all over the country in the beds of rivers, in the past 30 years, for water supply or the conveyance of oil or other commodities.

These pipes, however, are the largest in diameter ever laid in this way, and the Hackensack River crossing presented unusual obstacles in great depth, 41 ft. below low water; a very swift tidal current; a somewhat uncertain bottom; and considerable navigation to contend with.

The original proposal to carry the single full diameter, riveted steel pipe used on land, under the beds of the two rivers, instead of breaking up into smaller pipes, or using cast-iron flexible joints, as had been done heretofore, was made by the writer in a bid of the Rockaway & Hudson Co. to Jersey City, in January, 1898, in which the pipe was to be 60 ins. in diameter. The plan was adopted, and the estimate based thereon, after consultations with Mr. Wood, President of the Maryland Steel Co., who was interested in the proposal, and the assurance on his part that his company would undertake to build and lay the pipes substantially as it has now been done. All propositions were rejected at that time by the city.

After the award of the contract to P. H. Flynn, assigned to the Jersey City Water Supply Co., in February, 1899, the writer was called upon to lay out and perfect the plans for the aqueduct line, and designed a 72-in. pipe crossing, to be built up on the shore to the contour of a trench beneath the bed of the river, by using bevel joints, no reliance being placed upon the elasticity of the pipe to secure conformity to the contour, as had been done to a certain extent in the case of the 16-in. pipes laid by Mr. Clemens Herschel across the Passaic. The essential requirement in laying such a pipe was that it should not, at any time, be drawn on or touch the bottom until fully across, but should be considered as a rigid girder, and as the lengths were projected into the river, the pipe should be supported by pontoons, and temporary piled bents, at intervals not further apart than the safe limit at which the pipe, as a girder, would span without danger of injurious strain and distortion; the supporting cables being adjusted in length as the pipe advanced by reference to a fixed plane or chord, as the river surface, so as to preserve, in all positions, the rigid form or contour, as it developed, without strain, and allow each support to carry an equal load.

As originally planned, the pipe was to have been protected by wooden lagging or boxing, temporarily braced inside at points of support, and allowed to fill with water, and to be supported about every 100 ft. At all times and positions the outshcre lengths would be under water and, between two or more supports in the channel, below the deepest draft vessel navigating the river. When completely across the pipe would be parallel with the trench contour and would be lowered into its bed, evenly and simultaneously from each support, and then protected by gravel and riprap lowered over and around it. The water could be then pumped or forced out, and any small leaks calked, and the inside painted where abraded.

This plan was approved by the U. S. Board of Engineers, having control of the navigation of the rivers, in the fall of 1900, and by the Secretary of War, in January, 1901.

It will be seen that it differs radically from the methods pursued in laying the 16-in. pipes, in 1895, and other submerged pipe, in:

(a) The pipe being considered as rigid, and no advantage taken of flexibility.

(b) Not being drawn over the bottom, but suspended in the water at the varying heights above the bottom necessary to preserve its rigid form.

(c) Being built up with bevel joints to an arbitrary contour, fitting another arbitrary contour given to the trench beneath the river bed, by dredging. The bottom of the trench being determined by the depth at which stiff silt or other safe material could be found beneath the soft bottom mud.

The final plan adopted, and by which the work was done, contained another entirely original feature, suggested by Mr. J. Waldo Smith, Consulting Engineer of the company, and Mr. Wm. B. Fuller, Resident Engineer in direct charge of construction. This was to cover the pipe with continuous rings of armored concrete, of sufficient weight to just overcome the buoyancy of the empty pipe, and by drawing the pipe across empty, secure a larger span between supports, and the advantage of being able to detect leaks by reason of defects in calking during the whole operation, and a better, lighter, and more reliable protection to the outside of the pipe, than could be secured by riprap lowered in deep water.

The concrete rings being grouted to the pipe, and to each other, relieved the sheets of steel in the pipe proper from all compression strains, in resisting bending, which they were least able to resist, and left the steel liable to tensile strains only.

It should be noted that the whole design and method being based upon the pipe being considered as a rigid girder, and ignoring any flexibility, the addition of the rings only made the girder stiffer and stronger, substituting for the thin plate the compressive strength of concrete in the upper chord, as it were.

Experience at the Hackensack River proved that, notwithstanding the careful work of the subcontractor, it was a practicable impossibility to dredge in deep water, in a current carrying large amounts of silt in suspension, a trench with a bottom just to the contour designed, so that the pipe, when lowered to its bed, would have an even and continuous bearing.

Profiting from this experience, the trench at the Passaic River was dredged somewhat deeper than the theoretical bottom, and the pipe held suspended over it at the proper grade while sand was pumped in under and around until it was thoroughly and evenly supported at all points. Mr. Herschel never had any official connection with the Jersey City Water Supply Co. His interest in the work was temporary, only, and incidental, as adviser to a possible financing syndicate, during abortive negotiations for a construction loan; at which time Mr. Herschel examined the whole enterprise as far as developed and, I believe, approved and advocated the essential features.

Respectfully, E. W. Harrison, Chief Engineer,
Jersey City Water Supply Co.
15 Exchange Place, Jersey City, N. J. Mar. 28, 1903.

(We take pleasure in giving space to this communication, both because of the valuable technical information which it contains, and because of some misstatements, and of some statements that may have given rise to wrong inferences, in the article in our issue of March 12. Through inadvertence, the names of Messrs. Smith and Fuller were omitted from the article in question, and Mr. Harrison was cited as consulting, instead of chief engineer. The credit, actual or implied, given to Mr. Herschel for having taken any part in the design of the crossings, through suggestion or otherwise, was due to a misunderstanding on our part.—Ed.)

The Pay of Engineers Connected with the U. S. Coast and Geodetic Survey.

Sir: I desire to call attention to two items, the one in your last issue regarding the civil service examination for the position of Aid in the U. S. Coast and Geodetic Survey shortly to be held, the other appearing in a Washington dispatch in the "Sun" of April 2 regarding the work of Miss Mary E. Prettyman, a typewriter in the U. S. Patent Office. The examination referred to includes all those subjects upon which a young man must spend the best part of four years in a college or university course in order to fit himself for topographical engineer, namely, mathematics, practical computations, astronomy, physics, surveying, modern languages, drawing and descriptive geometry, to say nothing of the hundreds of dollars required for tuition. And from the eligibles resulting from such examination it is expected that certification will be made to fill twelve vacancies in the position of Aid in the Survey *at a salary of $60 per month*, or $720 per year.

The other item deals with the fact that Miss Prettyman holds the championship in typewriting in the Department and receives the salary of $720 per year.

From this showing it would seem that so far as the pecuniary consideration goes, it would pay the young men who are about to take a college or university course to pause awhile and enter a business college instead, for if they can engage at a salary of $60 per month they will save both dollars and years.

I simply wish to call attention to the pecuniary conditions involved, and suggest that there is certainly something wrong with what the Government have to give for what they want in return. If this is not a case of wanting something for nothing I am much in error. Surely "Uncle Sam" is rich enough to pay at least a fair price for the goods he wants without resorting to such sharp practice, for I can call it nothing else. Yours truly,

Oliver B. Harden.
20 West 34th Street, New York City, April 3, 1903.

(In considering the rate of pay received by young men on entering any profession and comparing it with the earnings of those doing clerical work, it must be remembered that the professional man is in the line of promotion to a higher grade of work. In the U. S. Coast Survey at the present time the appropriations made by Congress for salaries are as follows: 23 Aids at $720; 6 Aids at $900; 8 Assistants at $1,200; 3 at $1,400; 4 at $1,600; 3 at $1,800; 8 at $2,000; 8 at $2,200; 1 at $2,400; 5 at $2,500; 5 at $3,000; 1 at $3,200; 2 at $4,000. There is, however, in the Survey at present no prescribed rate of increase of pay for length of service. That our correspondent's view is not without some justification is shown by the fact that Superintendent Tittman, of the Coast Survey, in his last estimates submitted to Congress, asked that the pay of Aids on entering the service be raised to $1,000 per annum. On the other hand, it must be remembered in making any comparisons that Aids receive a large part of their living expenses in addition to their salary of $60 per month, that the appointment is a permanent one during good behavior, and that the work is very healthful and pleasant and attractive to any young man fond of out-door life.—Ed.)

Notes and Queries.

The recent receipt of several communications for publication signed only with initials or with a nom de plume, leads us to call attention here to the rule that all communications should be accompanied by the name and address of the writer. These may be published or not as the writer prefers, and in case publication is not made they will be treated as confidential. They must in every case be furnished to us, however, or the letter cannot be published and obviously cannot be answered.

Mr. Walter H. Sawyer, Treasurer of the Union Water Power Co., Lewiston, Me., desires the addresses of persons or companies who design and install apparatus for burning powdered fuel under tubular boilers. So far as he can find none of these systems are in practical use in the East.

We may note that the most extensive use of powdered fuel in the world is doubtless in connection with the rotary kiln process of manufacturing Portland cement. The success achieved here gives favorable ground for achieving a like success under boilers; although the complications involved would tend to confine the system to plants of large size.

Mr. F. E. Holiday, Teacher of Geology and Physiography in the Manual Training High School, Kansas City, Mo., has sent us the following inquiry:

Myself and students are at work gathering data for a very minute model of Kansas City—horizontal scale to be 4 or 6 ft. to the mile—for the St. Louis World's Fair. Can you cite me to any publication or individual who can give me fully experiences and suggestions as a result of practical work in making large plaster of Paris or paper pulp models? We have done a great deal of the work on a small scale in paper pulp, but not in plaster of Paris.

I should especially like to be informed as to the details and precautions necessary in modeling from plaster of Paris, and the expense of material and where it can be procured.

In our issue of July 13, 1899, we published an article on "Relief Map Construction," by Frank G. White, based on a paper in the Proceedings of the Iowa Engineering Society for 1899. Mr. W. H. Jackson, Vice-President Des Moines Bridge & Iron Works, Des Moines, Ia., is now secretary of the society named. In our issue of July 27, 1899, there was a letter on the same subject from Mr. E. E. Metts, War Department, Chickamauga and Chattanooga National Park Commission, Chattanooga, Tenn. In Vol. X. (1881-2), Trans. Am. Inst. Mining Engineers, there is a brief article by Mr. O. B. Harden, of Philadelphia, on "Topographical and Geological Modeling," which describes the preparation of models and casts therefrom, as well as a wax for making models and plaster of Paris for casts. Some general hints might be obtained from "A Description of the Topographical Model of Metropolitan Boston," by Geo. Carroll Curtis, Sculptor, of Boston, Mass. The pamphlet was published in 1900 by the Board of Paris Exposition Managers of the Commonwealth of Massachusetts. We may add that the method of relief map construction described by Mr. White in the first of the articles named is one of the simplest and best which has ever come to our attention. It consists, in brief, of building up the map in sheets of thin, easily-worked material, cut to contour lines, from the lowest levels, upwards. Each section of the map, in the rough, shows a series of steps, which may be so designed as to be filled in with a plastic material, or shaved off, so as to conform to the proper slope. Finally, for methods of working in plaster of Paris, and allied topics, references may be made to "How Plaster Casts are Made," by Frank Forrest Frederick ($1.50); while the material itself, and its price, ought to be easily obtained from any well-equipped dealer in artists' or in masons' materials for buildings.

FAILURE OF A CONCRETE FLOOR IN A MILWAUKEE BUILDING.

The failure of a concrete floor in a new building at Milwaukee on March 28, appears (as far as can be ascertained at present) to have been caused by failure of the falsework before the concrete had set, as in the case of the Chicago accident described in our issue of Dec. 4, 1902. As we have noted elsewhere, it is probable that many of the men entrusted with the design and construction of concrete work of this kind do not realize the great weight of a mass of wet concrete reinforced by steel bars and rods. The Milwaukee building is a four-story structure with brick walls; the columns, girders and floors are of the Ransome system of concrete-steel construction. The accident occurred in the front panel of the top floor, extending the width of the building, and the fall broke the same panel of the completed floors below. All the other parts of the floors are intact, but an investigation will be made of all the concrete work. Various causes of the accident are spoken of; including carelessness in the concreting and lack of skilled supervision of both the timber construction (falsework) and the concreting work. Investigations are being made independently by the parties interested, but no report has yet been made. The architect was Mr. Esser, and the contractors were A. Monsted & Co., of Milwaukee. The structure is a factory and office building, and was being erected for the Johnson Electric Service Co., makers of pressure and temperature regulators, etc. In response to an inquiry we have the following letter from Mr. W. S. Johnson, president of the Johnson Electric Service Co.:

Sir: The first sentence of your letter stating that you understand that a concrete building under course of construction had "failed or collapsed" is the keynote probably of what will be reported throughout the country. No building has failed or collapsed that we are connected with. We are building a large building having brick walls with concrete floors. The system of concrete construction used is the Ransome. There is nothing new about it. As you know, there are tie-rods but no netting. The same construction has been used for the past 10 years in many places in the United States. The concrete we are using is made of 5 parts crushed stone, 2 parts sharp clean sand, and 1 part Atlas Portland cement. Tests of the concrete throughout the building show it to be first-class in every respect.

On Saturday, March 28, the concrete men laid a concrete flooring upon falsework, 55 × 18 ft. Just after they completed the work, something gave way, undoubtedly connected with the falsework; this precipitated the floor upon the next floor, which supported the falsework. This, of course, carried down what we call two squares through the building, breaking solid concrete and bending and displacing the rods. No columns of the building fell. A portion of the wall of the building was forced to fall, as the concrete was tied into the outside walls by numerous metal ties. The fall through the building of this mass was unfortunate, but the total loss will probably not exceed $5,000, and had nothing whatever to do with the support of the building. The concrete work is now being examined by the best experts in the United States. The building is absolutely fireproof, as there are not even wooden floors in the building, nothing wood about it except the window sash.

ROOFING TILE nearly four hundred years old have recently been found on an old mill near Zug, Switzerland. The mill was torn down a short time ago, and a small part of the roof was found to be covered with tile marked with the date 1549. The tile, which thus appear to be over 350 years old, were still perfectly sound and unaffected by the influences of the weather.

ORIGIN OF PEBBLE-COVERED PLAINS IN DESERT REGIONS.*

By William P. Blake, M. Am. Inst. M. E.†

The attention of travelers, upon the desert bordering the Great Colorado of the West, is often arrested by broad stretches of pebble-covered plains, or mesas, glittering in the sunlight from the myriads of polished surfaces, giving, at a distance, the appearance of a sheet of water. It is not alone the well-rounded, polished surface of these pebbles which commands attention, but, in addition, their nearly black or dark-brown color; and, above all, their uniform distribution in a level sheet, covering the plain in a continuous layer or pavement like a vast mosaic without sand or soil. Hundreds of square miles along the lower Colorado, especially in Yuma county, Arizona, and on the borders of the Colorado Desert in California, are thus covered. It is evident that the former extent of such pebbly plains was much greater than now, for the continuity of the mesa is broken into by the numerous dry arroyos or "washes" formed during exceptional showers or deluging rains.

In some places there is an underlying bed of pebbly conglomerate, a mixture of pebbles and sand; in others the pebbles rest on a sandy, earthy foundation. The rounded pebbles are distinctly alluvial in origin, and pertain to the ancient Colorado drainage system; but it is not comprehensible that such regular layers of polished pebbles could have been left by subsiding floods or river action.

Attention was early directed by me to these remarkable plains, first examined in 1853, when exploring for the United States and seeking a practicable route for a railway to the Pacific coast.‡ The cut and polished surface of the pebbles and of loose rocks on the desert was then correctly explained as due to the attrition by wind-driven sand and dust, but an explanation of the pavement-like surface and the accumulation of pebbles and rock fragments in close contiguity was not attempted.

The object of this paper is to offer an explanation and to add to our knowledge of the phenomena of æolian denudation.

It appears certain that the surface sheet of pebbles, and in many localities of small fragments of rock and bits of fossil silicified wood, is the result of an accumulation by the gradual removal, by the wind, of sand, silt or finer materials from around and below the pebbles, undermining them, removing their support, and permitting them to fall to a lower level, where they accumulate by concentration until the whole surface is closely covered by fragments too large and heavy to be moved away by the wind. Such a deposit of pebbles or fragments may thus represent all that were originally distributed through several feet of thickness of sand and lighter alluvions. In this way there may be a removal of a large amount of fine materials from the general surface of a region, lowering its level, until, by the complete covering and protection of the surface by the concentration of the heavier fragments, æolian denudation is arrested, and the further lowering of the surface is stopped.

PERFORMANCE OF B. & W. BOILERS IN U. S. S. "MARIETTA," AND THE SUCCESSFUL OPERATION OF MARINE WATER-TUBE BOILERS. §

By Henry C. Dinger, Ensign, U. S. N.‖

The two Babcock & Wilcox boilers of the "Marietta" are now nearly six years old. The vessel was put in commission in September, 1897, and has had active service ever since. During this period she made the voyage from the Pacific Coast to Santiago, Cuba, to join the naval force of Admiral Sampson. It was only because the country was more concerned in the fate of the "Oregon" that the brilliant service of the gunboat was overshadowed by the work of the battleship, and thus the fear of the "Marietta" in reaching the blockading line in practically perfect fighting trim never received the recognition that should have been accorded the smaller of the two war vessels that came from the Pacific to battle with Cervera's fleet.

Since the termination of the Spanish-American war this vessel has made a cruise to China and the Philippines. In the waters of the latter she was under way most of the time for a year. During the last eighteen months she has cruised almost continuously in West India waters, between ports where it is not possible to make machinery repairs on shore or to purchase engineering supplies. Probably no vessel in the Navy during the past five years has steamed as many miles, for the "Marietta" has logged over 80,000 knots during that period.

SMALL AMOUNT OF REPAIRS.

During these years of service the boilers very seldom required the assistance of any other help than that of the ship's force. The following is a list of repairs made since she has been commissioned, by other than the ship's boilermaker and his helpers:

(a) Renewing firebrick around fronts of furnace with cast-iron liners at Boston Navy Yard, July, 1899.
(b) Renewal of ash pans at Boston, July, 1899; Portsmouth, October, 1901, and New York, June, 1902.
(c) Retubing feed heaters, Boston, July, 1899.
(d) Replacing 17 tubes of feed heater, New York, June, 1902.
(e) Renewing a small portion of the casing, New York, June, 1902.
(f) Renewing lagging on steam drum and pipes about the boilers.

The renewal of much of this lagging might be more properly charged to repairs to piping, since it formed no integral part of the boiler.

On board large warships, where it is possible to carry spare material, every one of the repairs that were made at a navy yard could have been effected by the ship's force. It was simply because material was not available that such repairs were not made on board the gunboat "Marietta."

PRESENT CONDITION OF BOILERS.

The boilers are now in good condition, and everything about them in general is working well. They have not received any special care, but, on the contrary, have had unusual and severe service. No special precautions have been taken to insure a supply of perfectly pure water, although the fact has been fully appreciated that purity of feed is essential in the operation of all water-tube boilers. Salt water sufficient to bring the saturation in the boilers up to $^1/_{32}$ has been used; the ship has cruised at full speed many times for several days with this saturation without any bad results at the time nor afterwards. However, every effort was made to maintain a fresh feed at all times. At no time has a long period been required for repairs. No rupture of tubes or headers has taken place, nor has there been any dangerous overheating.

Considering the fact that the "Marietta's" installation of water-tube boilers was one of the first of this type to be put into any war vessel, and that she has had no firemen specially trained in the management of marine steam generators of this design, the results secured are more than satisfactory.

DRYNESS OF STEAM GENERATED.

Dry steam seems to be furnished under the severest of conditions. Priming has never occurred. Whether the ship is rolling, the feed water dirty, fires forced or caustic soda admitted for neutralizing the acids, the quality of the steam seems unimpaired. The carrying over of water into the cylinders has never been noticed, and therefore practically never anticipated by the force on watch, and no separator is fitted.

NO AUTOMATIC FEED REGULATORS NECESSARY.

Even when the boilers are forced at short notice, a steady water level has been very easily maintained. The supply of feed water is therefore regular, and involves neither mental strain nor physical exertion upon the part of the water tenders. This regular supply of water has been secured without the installation of any automatic devices for regulating the flow. The boilers are fed by two vertical simplex pumps. For feed purposes a pump is kept in continuous operation, and by varying its speed the output is regulated. Within narrow limits the supply is regulated by the check valves at the boiler.

EFFICIENCY OF THE BOILER.

The boilers are efficient, about 2¼ lbs. of coal per HP.-hour being required for general purposes. This includes the operation of auxiliaries, and auxiliaries on all warships are extremely wasteful. The smaller the ship the more wasteful the auxiliaries, since they are installed in all manner of inaccessible places and form a greater percentage of the total power. As overhauling of auxiliaries badly installed is difficult and vexatious, even important repairs are only attempted when absolutely necessary. When measured upon the basis of the amount of water evaporated, the efficiency of the boiler varies from 60 to 70% of the very best trial conditions. This evaporation cannot be compared, however, with trial results where picked coal is used and other conditions conducive to economy prevail. On board the warship, where emer-

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‡"Report of a Geological Reconnaissance in California," vol. V. "Pacific R. R. Reports," pp. 108, 112, 117.
§From the "Journal of the American Society of Naval Engineers."
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emergency orders often require the commander of the vessel to coal at night, when all manner of worthless fuel may be forced upon him, where coal is finely broken up by numerous handlings and where a mixture is often used, the results attained on board the "Marietta," as regards efficiency, are good, and will compare well with actual results secured under any other type of marine boiler.

ARRANGEMENT AND SIZE OF THE FURNACES.

By reason of the fact that each boiler has but a single furnace, although the firing is done from three doors, the output of the boiler decreases rapidly when any furnace door is open for a considerable time, such as when fires are cleaned. Where a sufficient number of these boilers should be arranged in battery, cleaning the fires should not

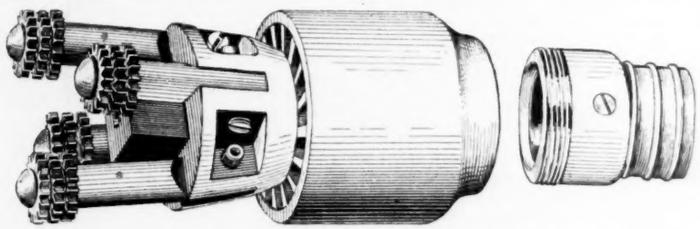


FIG. 1. TURBINE TUBE CLEANER FOR WATER-TUBE BOILERS.

interfere with the uniform steam supply. Fair results have been attained even from this single furnace installation. The ship has not had exceptionally skilled firemen. By persistent training expert stokers have been secured at times, and then an increased output of evaporation has been secured.

Owing to the unusual inclination of the grate from front to back, the work of firing is somewhat difficult. This labor, however, is not of a severe nature, and when the men become accustomed to the unusual arrangement of grate, good results are secured. This sloping of the grate was ordered by the Bureau of Steam Engineering, to increase the volume of the combustion chamber.

The temperature of the boiler room in the hottest weather at the places where the men work seldom exceeds 108°. In the vicinity of the steam drum, where there is considerable piping and where new joints might have to be made, it becomes very warm.

DEFECTS MOST LIKELY TO OCCUR.

The most frequent defect encountered is leakage from the caps closing the openings over the 4-in. tubes on headers. These leaks have never been serious, though the slight resulting loss of water is annoying. It does not require particular skill to fit these caps. Experience shows it is best to dispense with gaskets in securing a joint, and to depend upon good metal-to-metal joint.

When the ship was first commissioned, the caps were ground in with glass or emery, but later a special milling tool was made for facing off the seats. This tool insures more rapid and satisfactory work. After facing the caps good results have been secured by giving a coating of black lead or graphite to the joint. Where the seating is bad, and where the milling machine cannot be readily used, gaskets have been made of "rainbow" packing, sheet copper or oiled paper. These gaskets must be carefully fitted. The joints thus made have proved tight where skill and care have been exercised in fitting the gasket. In general, the use of gaskets should be avoided, because when they blow out the resulting leakage is much greater than the loss of water from the slightly defective metal joint.

When there is a serious leak from a cap the cause is generally the giving way of the dog. The metal around the hole in these dogs or lugs occasionlly splits, and by the enlargement of the hole the cap is loosened and drops out of place to a very slight extent. This defect fortunately has seldom occurred, and with ordinary care can be detected before it becomes dangerous. Difficulty has also been experienced by the cracking of a few of the caps.

LITTLE TROUBLE EXPERIENCED WITH SCREW PLUGS.

The composition screw plugs closing the openings over the 2-in. tubes give comparatively little trouble. When it has been found necessary to renew them the work has been easily done. As these plugs are neither subjected to the action of the flame nor exposed to any undue heat, impairment is of rare occurrence. The steel headers into which these caps fit have not yet shown signs of deterioration from galvanic action.

ENDURANCE OF BOILER TUBES.

In both boilers the lower row of 4-in. tubes have been renewed twice. Such renewal has been found necessary by reason of corrosion of the lower surface of the tube just inside the front header, because there is a pocket there which collects sediment and permits of but little circulation. The impairment of these tubes was first noticed by their bending up, which tends to pull the corroded half of the tube out of the header and starts a leak at the expanded joint in the front header. The renewal of these tubes has been easily accomplished both at sea and in port. Special care has been exercised in keeping track of the condition of the tubes near the front header, so that the tube can be removed before a rupture or excessive corrosion takes place.

But very few good tubes have been found bent, almost all the latter being those which have been corroded and burnt. Practically no other leaks have occurred at the expanded joint, although the tube has been secured and made tight by an ordinary expander.

TUBES EASILY RENEWED.

None of the 2-in. tubes of the boiler have as yet shown any signs of giving out. The renewal of an ordinary tube is not a difficult job. Fires, of course, must be hauled, caps removed, the expanded end cut and bent inwards, and then the tube can be quickly withdrawn by anyone who has had experience in this repair. The renewal of any one tube does not impair the tightness of any of the others.

Cast-iron plugs for closing the ends of the tube were supplied the ship when she went into commission, but these plugs have not given satisfaction. It is much more satisfactory to put in a new tube, as reliance can be placed upon such a repair, and probably as much time would be required to fit the plug as to renew the tube. Fires have been hauled, three tubes renewed and steam gotten up again in ten hours, more than half of this time being taken up in allowing the boiler to cool and then getting up steam. About this time is required for the repair under ordinary conditions. When haste is essential the work could be done in much less time. When a boiler is cooled the renewal of a tube can ordinarily be done in one hour.

In case a tube in the middle of the box was badly ruptured the deformation thus caused might prevent the withdrawal of the tube through the hole in the header, and thus it might be necessary to cut out a number of other tubes to permit the defective one to be dropped into the furnace. During the five years of service of this vessel there has not been a deformed tube or one with its end bent which the ingenuity and skill of the engineers' force have not removed in the ordinary way and with but little trouble.

The tubes of the two heaters were renewed after the first two years' service of the ship. Practically all the tubes now in the heater have been there 3½ years. Whatever renewals have taken place since 1899 have been due to the tubes having become very hot.

The life of the tubes of the heater is longest when the appliance is in continual use. It is the intermittent or non-use of this auxiliary which hastens corrosion. When the boiler is not in use the heater should either be kept perfectly dry or completely filled with water.

In order to decrease the corrosion of the heater tubes, lime has been used in the feed-water heater. By giving a very fine coating of lime to the surface of the tubes it is believed that the rapidity of air corrosion can be checked. As the feed-water heater has been installed in the uptake, increased efficiency has been secured by its use. And yet, by reason of its location, it collects much dirt. It is very inaccessible for repair and cleaning, and has proved itself in general a rather annoying and troublesome appendage. Though not a part of the boiler, it is an auxiliary which has contributed to economy in coal consumption.

BAFFLE PLATES NEED RENEWAL.

By reason of long use and the excessive heat to which they are subjected, the baffle plates are badly warped. The baffle plates of corrugated sheet metal resting on the lower row of 4-in. tubes are burnt away to a large extent. The upper layer of baffle plates is likewise impaired, but not to the extent of the lower ones. The renewal of the badly warped lower layer can only be done by cutting out some of the 4-in. tubes and by removing portions of the casing.

Soot is liable to collect on the baffle plates, and it has not been found an easy matter to remove the accumulations thus formed. An air service has been installed for getting rid of this soot, but though not effective, it is better than nothing. A steam lance has also been used for getting rid of the deposit when under way, but this has not proved effective. The soot can only be satisfactorily and completely removed when fires are hauled, and then by the use of bars and brushes followed by the use of the steam lance when pointed by some one within the furnace.

BOILER CASING NEEDS RENEWAL.

The casing consists of firebrick and asbestos, protected by thin metal plates. Up to the present time the firebricks have given little trouble. The brick linings of the furnace fronts have been replaced by cast-iron ones, which are renewed about once a year. The asbestos lining of the casing is now beginning to crumble, and considerable renewal is necessary. Some of the firebrick on the sides of the boiler are burnt out.

The metal plates of the casing, particularly around the lower part of the boiler, now require extensive repairs. The lower portions of the supporting plates and channel bars show signs of considerable corrosion, due to the action of soot, ashes and bilge water. As much of this material is difficult to reach, and thus the preventing of corrosion has been impossible, the renewal of the greater portion of the channel bars would be extremely advisable, and they should be made of heavier iron.

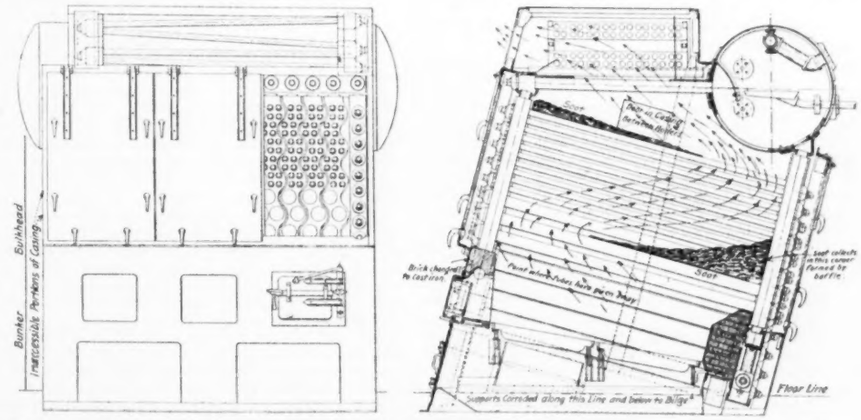


FIG. 2. FRONT VIEW AND CROSS-SECTION OF BABCOCK & WILCOX BOILERS IN U. S. GUNBOAT "MARIETTA."

TUBES OF THE FEED-WATER HEATER CORRODE RAPIDLY.

The tubes of the feed-water heater are most subject to corrosion, due to the presence of the air in the feed water. It has been observed that upon portions of these tubes small lumps of soft rust accumulate, and that under each lump is a pithole where rapid corrosion has occurred. The impairment of these tubes is first detected by the interior of the tube becoming rough. Once a tube ceases to be smooth its renewal may at once be anticipated.

The heater should be kept constantly filled with water, for corrosion is greatly hastened by permitting hot air to accumulate in the upper portions. The burning of the tubes is also liable to occur if there is any failure to keep the heater filled.

THE AVERAGE STEAMING PERFORMANCE OF THE BOILERS.

Probably no better testimony could be given as to the actual performance of the boilers than to state that under favorable conditions as high a rate of evaporation can now be secured as when the boilers were new. The official logs will show that this declaration can be sustained. Under natural-draft conditions, for a period of eight hours, and with only the regular steaming watch stationed in the fire room, the boilers recently furnished to the engines over 80% of the contract trial power—an amount actually exceeding the original designed power. The fuel used was Pocahontas coal that had been mined

over a year previously, and which, in the meantime, had been exposed for a considerable period to wind and weather. The coal consumption during this run was 2.22 lbs. per HP. for the propelling engines and 2.39 lbs. per I. HP. for all purposes.

The following data is taken from official logs for six hours, August 11, 1902:

Speed, knots				11.9
Sea				Smooth.
Wind				Bow.
Grate surface, square feet				94
Heating surface, square feet				3,664
Coal per hour, pounds				2,045
Revolutions, engines	starboard,	200.45;	port,	200.48
Steam in boiler	"	172 ;	"	172
Steam at engines	"	170 ;	"	170
Vacuum	"	21 ;	"	20
Horse-power	"	421.25;	"	414.25
Total horse-power				863.5
I. HP. per sq. ft. of heating surface				221
Pounds of coal per I. HP. for all purposes				2.39
Pounds of coal per sq. ft. of grate surface				21.75
Temperature, feed, degrees Fahrenheit				128
" injection, degrees Fahrenheit				82
" discharge, degrees Fahrenheit				116
" engine room, degrees Fahrenheit				130
" fire room, degrees Fahrenheit				108

The auxiliaries in operation included the dynamo, steering engine, three ventilating blowers, ash hoist and the following pumps: Air, circulating, feed, bilge, sanitary and the auxiliary air and circulating.

It will be noticed that a very poor vacuum was obtained,

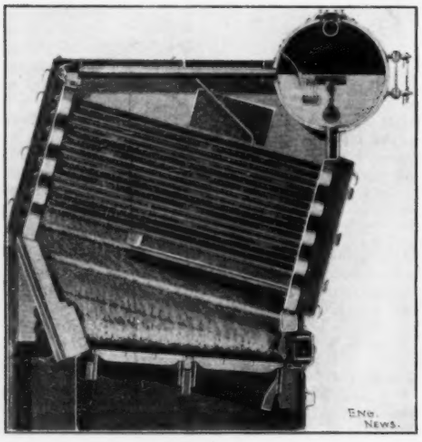


Fig. 3. Babcock & Wilcox Boiler in U. S. Cruiser "Cincinnati;" Section Showing Path of Hot Gases.

due to the fact that the performance was made in hot weather, when the injection water was very warm.

AVERAGE PERFORMANCE OF BOILERS FOR FIVE MONTHS, WHILE CRUISING IN THE TROPICS.

During the past five months, using Pocahontas coal obtained at San Juan, Kingston, Trinidad and Curacao, running at speeds varying from 9 to 12 knots, encountering smooth to moderate seas, and, with an ordinary fire-room force, the average performance has been as follows:

Speeds 9 to 10 knots: coal per I. HP., for all purposes, 2.5 to 2.31 lbs.

Speed 10 to 12 knots: coal per I. HP., for all purposes, 2.9 to 2.41 lbs.

Using half maximum power: average coal per I. HP., for all purposes, 2.45.

Using three-quarter maximum power: average coal per I. HP., for all purposes, 2.75.

As in the case of all small gunboats, the auxiliaries are necessarily wasteful, due to the manner in which they are installed. From actual experiment the auxiliaries used from 250 to 350 lbs. of coal per hour. Deducting the amount used for auxiliaries, and only taking into account the amount of coal used by the main engines, the following average results are obtained:

Speed, 9 to 10 knots: coal per I. HP., 1.9 to 2.3 lbs.; average, about 2.15 lbs.

Speed, 10 to 12 knots: coal per I. HP., 2.3 to 2.8 lbs.; average, 2.49 lbs.

The evaporative efficiency from and at 212° F. is from 8.5 lbs. to 10 lbs. of water per lb. of coal, giving a boiler efficiency of from 60 to 70%.

When both boilers are in use and about 1,000 HP. is developed, the make-up feed averages about four to five tons of fresh water per day. The evaporator installed (capacity 1,600 gallons per day) not only supplies all the make-up feed, but insures a liberal allowance for ship's use.

DANGER FROM SCALE.

The tubes are likely to become impaired by the presence within them of air, oil, dirt or scale. Scale is the evil that should be most dreaded, since if care is exercised the introduction of dirt or oil should be prevented. Since the water tender can give a dose of salt feed at any time, and as he will certainly give such a supply rather than run the risk of getting low water, some salt water undoubtedly goes into the boiler every day. It also may come from leaky valves. The auxiliary feed pump is the only pump fitted for pumping fire-room bilges. If, however, from any cause considerable scale is allowed to deposit, the tubes are liable to burn out. If even a thin deposit forms, the evaporative efficiency is reduced. From salt alone no serious results need be apprehended, but no salt water ever enters without carrying some scale.

ILL EFFECTS IN DIRT.

The efficiency of the boiler is likewise lessened when there is even a slight coating of dirt in the tubes. A deposit of considerable thickness will produce conditions that will result in the burning out of the tubes. Skill in management and judgment in blowing down will prevent muddy sediment from collecting in the tubes. This sediment ought even to be kept out of the water legs, which portions, however, are not subject to the action of flame or severe heat. If dirty water is used, it is imperative to blow down regularly, so that dangerous accumulations of sediment cannot form. The mud-leg cap seats are corroded, due to sediment that has been allowed to remain.

OIL IN ANY BOILER A MENACE TO ITS SAFETY.

The strictest care should be taken in order that as little oil as possible may reach the tubes. As it is absolutely impossible to keep the tubes entirely clear of oil, since the oilers will pour oil into the auxiliaries, especially the feed pumps, even if they are sparing at the main engines, some means must be taken to neutralize its ill effects. This can be done by the use of caustic soda, the amount required being determined by special conditions.

On board the "Marietta" about 4 lbs. of caustic soda was used per week. It is also advisable occasionally to boil out the tubes by a strong solution of soda. Another way practiced on board this ship of getting rid of oil is to introduce about 10 lbs. of soda into the boiler, then get up steam quickly. After allowing the alkaline water in the boiler to stand for a time and thus neutralize the acid, the surface blow valve should be slightly used, and then the boiler should be emptied by means of the bottom blow valve. Where fresh water is scarce there will naturally be a disinclination to resort to this remedy.

Another way is to pump the boiler about one-third full of fresh water and then enter the soda. Admit a little steam through the auxiliary stop valve to heat the contained water. Then circulate the water through the boiler by means of an auxiliary pump, using any available auxiliary to effect this object.

It is regular and uniform cleaning, and not intermittent attention, which will insure efficiency and safety. The use of zincs is also advisable, the number and location of the baskets or slabs being dependent upon experiment, experience and character of the water.

MECHANICAL METHOD OF CLEANING INTERIOR OF TUBES.

The coating of the interior of the tubes of marine boilers is likely to occur, no matter how great the precautions that may be taken. From known and unknown causes the deterioration and pitting of condenser tubes takes place very rapidly in certain waters, and therefore condensers leak. Through carelessness in manipulating valves, and possibly through neglect to keep valves tight that communicate with the sea, scale-forming substances are admitted into the boiler, with the depositing of scale on the tubes as a consequence.

When the interior of the tubes thus becomes coated to any extent, either with sediment or scale, and this deposit cannot be removed by the introduction of caustic soda or petroleum, the cleaning must be done by mechanical means. It is not only a long and tedious, but oftentimes an impossible, task to clean the tubes of scale with wire brushes and scrapers.

There has recently been supplied to this vessel a turbine tube cleaner, Fig. 1, and with this tool the tubes can be effectively cleared of scale. The water supply for operating this little turbine is supplied from the auxiliary feed pump through a small hose. The arms carrying the cutters are thus made to revolve by the strong impulse (100 lbs. pressure) of the water. The appliance is then shoved back and forth through the tubes. The spray of water discharged from the turbine washes away the deposit that has been loosened by the cutters. A 4-in. tube turbine cleaner requires three men to operate it—one to stand by the pump and two men to guide the tool.

It should be impressed upon the water tenders that such care should be taken in regard to the character of the feed that there will be no need of using such a tool as a turbine tube cleaner. It is a task of considerable magnitude for the ship's force to clean all the tubes of a water-tube boiler, since a very large number of joints will have to be remade, and a small amount of leakage is liable to occur from such joints after such extensive cleaning is completed.

SUMMARY OF ADVANTAGES.

(a) Simplicity.—In regarding simplicity as a primary or salient feature of the boiler, it should be understood that there should be first of all simplicity of design. Any steam generator which possesses attachments whose operation is not thoroughly understood nor completely under the control of a water tender who has not absolute confidence in their working, is certain to give trouble and prove inefficient for sustained sea work. Then there should be simplicity of construction. Finally there must be simplicity of operation, for that boiler will soon burn out which practically requires the undivided attention of a skilled man simply to look out that a safe water level is preserved.

(b) Dryness of Steam.—Dry steam has been furnished the engines under all manner of trying conditions. Both muddy and salt water have been used for considerable intervals, and a high gage of water has been carried in emergencies, especially when getting under way, without producing serious results or causing priming.

(c) Reliable Feed Maintained.—A steady and reliable feed can always be maintained. It does not require a specially trained or highly paid water tender to look out for things in the fire room.

(d) Simple Tubes Used.—The tubes are of simple straight lengths, care being taken to use the highest quality of material in their manufacture. Any attachment to a boiler invites trouble if it does not make it dangerous. As the tubes are straight they are very accessible for examination. Each tube can be moved independently of the others, and renewal can be made with ease by the ordinary ship's mechanics using simple tools.

(e) Rapidity of Raising Steam.—Steam can be raised quickly and fires suddenly hauled without subjecting the boiler to undue strain. The fires can also be rapidly forced without any ill effect to the working parts.

(f) Superior Material Used.—All the material used in

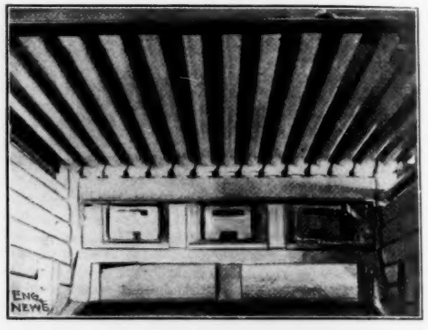


Fig. 4. View of Furnace from Bridge-Wall of Improved Babcock & Wilcox Boiler, Showing Absence of Fire Brick in Side Walls and Between Fire Doors.

construction is of superior quality. As an example, one of the feed-water heater tubes was reduced by being burned to a thickness of 34 B. W. G. in one place, and yet this tube resisted a pressure of 200 lbs. per sq. in. from the interior.

(g) Its Economic Efficiency.—The efficiency of the boiler will compare with that of any other marine water-tube steam generator. Under forced-draft conditions, also, its economic efficiency will compare favorably with any straight-tube boiler.

(h) Efficient Circulation.—The circulation of the water is natural and direct, and is not affected by the roll or pitch of the vessel. The endurance of the boilers of the "Marietta" ought to afford direct evidence as to the circulation of the water within the tubes. As the tubes are of large size, there is a continuous and reliable flow of water through them. The arrangement of the elements is such that the expansion of any one tube is uniform. As provision has been made for the proper expansion of the several elements, a leaky tube or joint is of very rare occurrence.

(i) Accessibility for Repair and Examination.—Practically all the vital parts are accessible for repair and examination. The cost of upkeep is comparatively small. With the exception of the headers, all the parts are procurable from many engineering supply establishments.

SUMMARY OF DEFECTS.

(a) Baffling Should be Improved.—The liability of the baffling to burn out, and the disadvantage if not the danger resulting from the excessive accumulation of soot upon these baffle plates, has necessitated much annoying work, besides a great loss in efficiency. The removal of the lower baffle plates cannot be done without cutting out some of the tubes.

(b) The Feed-Water Heater an Incumbrance.—By reason of the manner in which the feed-water heater is installed the rapid corrosion of tubes cannot be prevented, and some are also liable to burn out. This heater is also very inaccessible for repairs and examination. It is not an integral part of the boiler, but simply an auxiliary that was placed in the uptake in order to increase the efficiency of the boiler.

(c) Arrangement of Grate Bars.—The inclination of the grate bars practically renders the back end of the furnace useless for burning coal, because ashes will accumulate there on account of the difficulty of the firemen cleaning that portion of the grate so far removed from the furnace door. The details of furnace design are neither conducive to efficiency nor to good firing. The inclination of the grate makes stoking difficult and laborious. The combustion chamber is too small. The location of the baffle plates draws the product of combustion to the front of the furnace, thus making it almost impossible to clean the back portions of the grate bars.

(d) Design of Casing.—Various portions of the casing are too light for the purposes intended. Some parts are almost inaccessible for examination, cleaning and repair. The outboard casing of each boiler comes within a few inches of the bunker bulkhead, and thus the condition of these side casings is difficult to note. By reason of the ash-pit doors and the front casings not being tight but little forced-draft pressure can be carried, and when it is used the casings and uptake soon become red hot. By reason of the leakage of this front casing, the cleaning of soot from the tubes cannot be efficiently done.

(e) Location of Steam Drum.—The steam drum is attached to the back of the boiler, and this arrangement makes it extremely difficult for the water tenders and firemen to reach the valve that should be within easy access of repair and operation. Whenever men have to operate appliances at great discomfort and inconvenience, it is certain that such attachments will not receive the care that should be given them. It is even inviting danger to install appliances in such manner.

(f) Arrangement of Caps.—As the caps over the 4-in. tubes are so arranged that the pressure in the boiler tends to impair the joint, small leaks frequently occur from careless fitting of the plugs. It therefore requires skilled and intelligent men to fit the plugs.

PROGRESSIVE IMPROVEMENTS HAVE BEEN EFFECTED DURING THE PAST FIVE YEARS IN BABCOCK & WILCOX BOILER DESIGN.

In considering the defects of the "Marietta's" installationñ it should be remembered that the boilers of that vessel were designed over seven yars ago. Since that time progressive improvement has been effected in the details of construction of the marine boiler of the Babcock & Wilcox design.

In order to show the exact nature of the advancement that has been made in the construction of this type of boiler, a careful comparison should be made of the general drawings of the boilers fitted in the "Marietta" with those which will go into the new battleships which are known generally as the "Alert" type. It will be noticed that particular attention has been paid to overcoming the special defects encountered on the "Marietta."

It will be seen that vertical baffles are now used, thus preventing the accumulation of soot. The grate bars slope from back to front, or are horizontal, thus making it easier work for the stokers to fire efficiently. The casing has been made heavier, and care has been taken to prevent any leakage of smoke. The steam drums are now placed in front of the boiler, and all its attachments are in plain sight and can be easily operated by the water tender. The header caps are now so fitted that the pressure in the boiler tends to keep the caps tight.

As the installation of this type of boiler in the battleships and armored cruisers now under course of construction will permit more height to be secured than was possible on the "Marietta," a higher efficiency and increased endurance will be secured from the later design.

OBSERVATIONS AND SUGGESTIONS AS TO THE DESIGN, CONSTRUCTION AND OPERATION OF NAVAL BOILERS OF THE STRAIGHT WATER-TUBE TYPE.

As chief engineer of the "Marietta," there have been impelling reasons which made it incumbent upon me to familiarize myself with the merits and weakness of the Babcock & Wilcox boilers as installed in this ship. As the advantages and disadvantages of the design could only be appreciated by noting the performance of rival boilers, I have made special efforts to find out the merits and weaknesses of other straight-tube water-tube boilers by conferring with the chief engineers of the ships in which they are installed. I have found that the engineer officers of foreign navies have likewise considered the boiler problem as one of the most important within the domain of engineering. They have, therefore, been making a special study of the question, and are bent upon finding the best of the several types, so that they could be adopted in their own navy as the one of approved design. While the views herein set forth are not founded upon personal, practical experience of an extended nature, they still reflect, in great part, the judgment of men who have not only had experience, but excellent opportunity for passing upon the rival designs.

Simplicity must be one of the cardinal features of the naval boiler of the future. As the crews of warships may be changed at short notice, since such transfer often takes place when a ship is ordered to a foreign station, it is highly probable that an absolutely untrained fire-room force might be called upon with less than a few days' experience to operate water-tube boilers. This has occurred on the "Marietta" three times. Under such conditions it ought not to excite surprise if complicated designs of boiler should prove unsatisfactory and dangerous.

Endurance is an essential attribute. This does not simply mean the ability to work satisfactorily for a long period, but rather the power to withstand forcing, to endure some neglect and to possess a reserve factor of strength that will inspire confidence in the minds of those who are intrusted with its management as to the safety of the boiler when subjected to undue conditions.

Neither the efficiency nor the capacity of the boiler should be dependent upon the reliable working of separators, reducing valves or automatic feed devices. The manner in which chief engineers of vessels throw out of use steam and water traps ought to be conclusive evidence as to the reliance that should be placed upon automatic devices. Because an appliance works efficiently on shore, where there are no limitations as to the manner in which it should be installed, it does not follow that the same device will perform equally well at sea, where the conditions as to installation are entirely different. It may even be that these devices will work all right when operated on shore by exceedingly skilled and highly-paid experts, while on a war vessel their management would have to be intrusted to a fireman or petty officer. Even on official trial trips, where the test continues for a fraction of a day, and when the vessel is filled with the contractors' experts, the device may work satisfactorily for that period. On several trial trips the contractors have refused to use automatic feed devices, though installed on the boiler. When the more severe and continued tests of

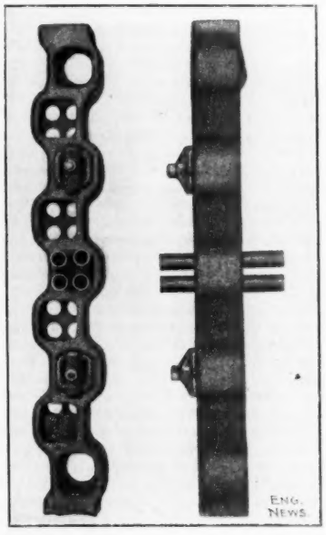


Fig. 5. Forged Steel Header; B. & W. Boiler, Showing Handhole Covering Group of Four 2-in. Tubes.

actual service are encountered the automatic device may prove utterly unreliable.

All complicated parts, such as intricate castings, unusual forms of tubes, special joints, or parts that require special tools for renewal are dangerous elemeuts, particularly on board a warship which may be called upon for blockading and for cruising duty, when it will be difficult, if not impossible, to secure duplicates of the intricate parts.

MORE SEA EXPERIENCE REQUIRED OF DESIGNERS OF MARINE BOILERS.

It is because many designers have but little knowledge of the crowded manner in which marine boilers and their auxiliaries are installed that they continue to force into naval vessels complicated boilers which can only be operated, even on shore, by specially trained men. Even to operate these boilers on shore for a fraction of a day it is essential that the manufacturers should be prepared to ship at immediate notice duplicate parts of every fitting and attachment.

In connection with this subject it may be of interest to recall the remarks made by Messrs. J. & A. Niclausse in reply to a criticism of their boiler made by Herr Von Jaski, of the German Navy, published in the February, 1902, number of the "Journal of the American Society of Naval Engineers." Messrs. Niclausse state in their reply that the trouble was due to the fact that the parts of the boiler were not put in place by their special tools in a special manner. The complaint was also made that the supervision of construction of the particular boilers was not made by one of the boiler company's experts.

It is reasonable to presume that both the system of technical education and apprenticeship at trades is as thorough in Germany as anywhere else in the world, and that the mechanics of that nation are artisans of skill and intelligence. In fact, there are people who believe that certainly, as respects technical education and apprenticeship indentures, Germany leads the world.

The fact that the Niclausse boilers are of such design and construction that they could be put together in the wrong way is presumptive evidence that the type is not fitted for naval needs. The complaint about these boilers does not come from Germany alone. There is some well-founded testimony to the fact that considerable trouble has been experienced on board the Russian naval ships with these steam generators. On board one naval vessel it was attempted to take down the header, and it required just as many days to do the job as it was expected it could be done in hours. The great weakness of this boiler will undoubtedly be found in the back end of the tube, due to the fact that it will be a very difficult matter to clean that portion of the tube, while it is the very part where nearly all the dirt and grease is liable to collect. The use of a small water turbine cannot be employed in cleaning out these tubes owing to the fact that only one end of the tube is open, and therefore there is liable to be an accumulation of deposit of a dangerous nature at the closed end of the tube.

In the design of the Niclausse boiler there has been too much striving upon the part of manufacturers to make boiler-shop tests and trial-trip tests for standards of performance. One might almost think that the boilers were constructed principally for the purpose of deriving data that could not be secured in practice and of securing trial-trip performances that it is not possible to duplicate in actual service.

BOILER TESTS SHOULD BE MADE UNDER ACTUAL SEA-GOING CONDITIONS.

The generally-discussed tables of comparison of various types of water-tube boilers are, as a rule, compiled from tests that cannot possibly be as severe as that to which the boilers will be subjected when installed on board a warship, where they are crowded beneath the protective deck, and where their operation is often conducted under enervating conditions. The utility, efficiency and durability of marine boilers should only be determined by extended and sea-going tests, for boilers that might stand the test of brief experimental work might become disabled under actual sea-going conditions where experts are not always at hand to assist the regular fire-room force.

On board the warship that boiler tube is a source of weakness which has a lantern or end attachment which might be wrenched off either in the insertion or removal of a tube. When one takes into consideration the fact that comparatively few men can acquire the sea habit, and therefore capable boilermakers will always be scarce at sea, simplicity of design becomes a cardinal feature in insuring efficiency.

Any boiler designed for working with absolutely fresh water, picked coal, efficient and reliable auxiliaries, expert care, and whose workmanship in some respects is like that of a watch, can hardly be expected to possess endurance. If, in addition to all these requisites, it is essential that uniform and expert stoking be done by the firemen, and that incessant care and watchfulness is essential upon the part of the water tender, it is certain that a low if not dangerous water level will inevitably be the result. If it is also imperative that special tools must be used in effecting particular repairs or doing necessary overhauling, then one is safe in predicting that such a steam generator is not likely to possess much endurance under the actual conditions that it will experience at sea at the hands of a strenuous stoker. The boiler for war purposes is one that can stand some neglect and some of the improper treatment that it will surely receive in actual service where untrained firemen and coal passers must be intrusted at times with responsible duties.

The use of special tools for boiler work is particularly objectionable. When work is carried on at sea upon boilers it is likely that there will be a pile of ashes and soot in the fire room, and it is very likely that, through the carelessness of some fireman or coal passer, the special tool might go overboard with the refuse. It is not altogether improbable that some evil-disposed person or one nursing an imaginary wrong might throw the tool overboard.

Provision must be made for gathering the sediment that is always bound to be produced in a boiler and conducting it away from the parts subject to the direct heat of combustion. This dirt should naturally flow to some place where it can be easily gotten rid of, and any boiler that cannot be entirely drained by opening a blow-off or drain cock at the bottom will be extremely difficult to keep clean when it is not most carefully and gently handled.

Too often but little attention is paid to the tightness of the casing. Its construction is very likely to receive a secondary consideration.

In order to secure endurance a marine boiler must be capable, at least for a time, of being operated even when dirt, oil or scale-producing substances are contained in the feed water. That naval boiler will soon reach the scrap heap, or be removed out of the warship by reason of its unsuitableness, whose feed supply can not be maintained within comparatively large limits by an ordinary pump operated by a fireman of average ability.

STEEL ROLLING DOORS FOR FREIGHT SHEDS AND ROUNDHOUSES.

For the large doorways of roundhouses, car sheds, freight houses, etc., rolling steel doors or shutters are now being very extensively used, as they are easy to handle (even in the windiest weather) and require no floor space, while ordinary swinging doors give trouble by sagging, by being difficult to handle in a wind, and by requiring a portion of the floor space to be kept clear. These rolling doors are composed of horizontal slats of steel so formed at the edges as to interlock, but giving sufficient flexibility to allow the door to roll up on a tube or roller. As these doors are liable to receive rough usage it is essential that they should be stiff enough to prevent bending or buckling in ordinary service, and the accompanying cut represents a door which is claimed to be specially stiff horizontally and flexible vertically.

The door is composed of slats or strips of steel, 3⅝ ins. wide, of No. 22 gage, which are rolled to the section shown in a single passage through a set of seven rolls, and then sheared to the required length. The absence from sharp bends and the tubular form of the edges are among the special features of the design. The interlocked

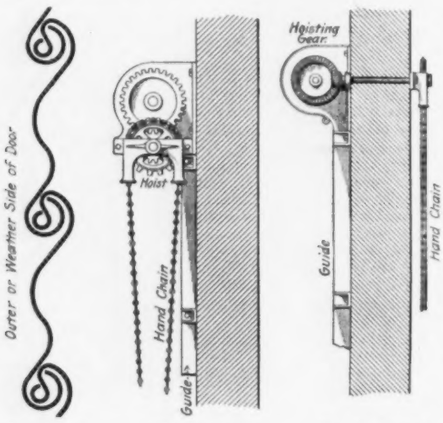


Fig. 1. Cross-Section Showing Form of Slats of Door.

Fig. 2. Operating Gear with Door on Inside of Wall.

Fig. 3. Operating Gear with Door on Outside of Wall.

Steel Rolling Doors for Freight Houses, Etc. Columbus Steel Rolling Shutter Co., Columbus, O., Makers.

tubular edges also form a species of roller bearing, increasing the flexibility and ease of operation, while reducing wear of the contact surfaces. The smaller tube within the larger one also prevents the possibility of the slats separating. The shape is such that water or snow cannot collect and cause rust, as will be seen by the cross-section in Fig. 1. When the slats are assembled they are prevented from moving laterally by pins driven into the smaller tube formed by the top of each slat, the pins being held by the friction grip of the tube. The pins have large heads, which slide within the angle iron door-guides so that there is no possibility of their coming out. No riveting is required.

The door winds upon a steel tube or roller mounted over the opening, and when rolled up it is protected by an iron hood. It is counterbalanced by a spring within the roller, so that it works very easily. The mechanism for raising and lowering the door is operated by hand by an endless chain, and the mechanism varies with the requirements. Two arrangements are shown in the accompanying cut; the spur gear shown in Fig 2 is for use where the door and operating chain are both on the inside of the building. The bevel gear shown in Fig. 3 is for use where the door is on the outside of the building and the operating chain is on the inside. For exceptional widths, as required for partitions in lecture or school rooms, etc., the door is operated by a bevel gear and crank handle. Fire shutters of the same type of construction are made, and are intended to be dropped only in case of fire. In this case the shutter is fitted with an automatic releasing device, consisting of a retaining bolt, which locks the roller when the shutter is raised. The bolt is attached to a vertical pivoted bar, held in position by a wire across the window opening (under the hood). This wire has at the middle a fusible connection, generally made to melt at 150°, and when this melts the release bar is freed and the bolt is withdrawn by a spring. The rapid closing of the shutter is assisted by a powerful spring within the shutter roll.

These doors are now in use at the Eberly wholesale grocery warehouse, the new shops of the Pennsylvania Lines, and the machine shop and freight house of the Hocking Valley R. R., all at Columbus, O. Those of the freight house are for openings 6 × 8 ft. The door in manufactured by the Columbus Steel Rolling Shutter Co., of Columbus, O., of which Mr. Peter Ebener, the inventor, is Superintendent.

THE NAVAL BOILER PROBLEM: TEST OF THE HOHENSTEIN BOILER.*

By Ensign John Halligan, Jr., U. S. N.

The water-tube boilers used in the several navies may, with few exceptions, be grouped in two classes: First, those with small bent tubes as commonly installed on torpedo craft: second, the large straight-tube type found on those naval vessels which are expected to do continuous steaming and to make foreign cruises.

The bent-tube types, by virtue of their elasticity of construction and assured circulation, combined with their relatively large combustion chambers, can be safely forced to a severe degree, provided the interiors of the tubes are kept clean, and the precaution is taken to prevent the accumulation of soot and scale between the tubes. The installation of this type of water-tube boiler is, in fact, the logical first solution of the effort to displace the Scotch boiler by one of lighter design. It was the inability of the Scotch design to withstand forcing, as well as the great weight of this boiler per horse-power when subjected to high pressures, that prepared a field for the introduction of the water-tube boiler.

In the effort to install large horse-powers in contracted spaces, it became necessary to provide for excessive heating surface per square foot of grate, and therefore in the bent-tube design the crowding of the tubes could not be prevented. The difficulty of cleaning the tubes under such condition, and the time and trouble required to locate and replace leaky tubes, conclusively showed that the installation of such types of boilers in naval vessels could only be justified by using them in torpedo craft or in small fast scouts. In fact, the bent tubes have to be renewed so often, and therefore the reliability of the boiler is so uncertain that most naval experts are now of the opinion that no type of bent-tube boiler should be installed in large vessels. Where regularity of steaming, economy and endurance are qualities of primary importance, it must be apparent that there is an advantage in, if not an absolute necessity for, the installation of the straight-tube design in battleships, cruisers and possibly gunboats.

The quality of endurance, however, must be the primary attribute in comparing the values of fire and water-tube boilers. When the Scotch boiler was forced to a comparatively severe degree the collapsing of crown sheets was of frequent occurrence, and the blowing out of an occasional tube—due to corrosion, pitting or grooving—could be expected from every boiler whose tubes had been in use for three or four years. There were cases when tubes commenced to go in six months. It was these common mishaps that caused the engineering experts of all nations to seek for a substitute for the Scotch boiler which would be an improvement on that well-tried type.

The water-tube boilers that were first installed had comparatively small drums, thin tubes and light casings, and they had only been in use in the several navies a few years when reaction set in against the type in general. The several weaknesses of the water-tube boilers soon became manifest, and therefore in the latest designs of both the bent and the straight-tube type the drums are being made larger, the tubes thicker and the casings heavier.

As a consequence, the weight of the water-tube boiler, particularly that of the straight-tube type, is more closely approaching that of the cylindrical or Scotch design.

In the report submitted by the British Admiralty to the House of Commons showing the relative cost of maintenance of the Scotch and the water-tube boilers, some surprising facts were ascertained. The average cost of repairs to the fire-tubular boilers of 50 vessels, where there was an aggregate installation of 520,400 HP., was $202.33 per 1,000 HP. per year. The cost of boiler repairs in 31 vessels, where there was an installation of 400,000 HP. of water-tube boilers, was $1,000.69 per 1,000 HP. per year. The comparison was made for a period of five years.

Fortunately for the prestige and efficiency of our navy, it has not been necessary for us to appoint boiler commissions to inquire as to the differences between the promises and the performances of a boiler selected as the approved type for the navy. It is by reason of the sound judgment and professional acumen displayed by the Engineer-in-Chief of the Navy in his selection of types of water-tube boilers for installation on board ships in the American Navy that we have escaped a similar humiliating experience. It has been due to his progressive and yet conservative policy, founded upon experiment and upon experience, that we have had no tale of dismay and disaster similar to that experienced in some other navies.

THE BOILER OF TO-DAY.

The straight-tube type of water-tube boiler possesses special facilities for cleaning and for renewing tubes. Its construction is characterized by excellence of details both as to material and workmanship. Comparatively high efficiency has been secured. Compared with the small bent-tube type, however, the straight-tube design is deficient as respects its ability to withstand more than a moderate degree of forcing. This weakness is either due to lack of elasticity of special parts, faulty construction, lack of circulation, or to a combination of these defects.

The limitations of the straight-tube type as regards its ability to be forced is recognized by the experts of every continental navy. It is evidenced by the unanimous recommendation of a special commission recently appointed by the French Minister of Marine. This commission was composed of four superior officers of the navy, who were directed to inquire particularly as to the type of boilers which should be installed on board three of the new battleships. After extended investigation this committee reported:

1. That all the new cruisers and battleships should be supplied with boilers having straight tubes.
2. That where straight tubes should be used, a greater combustion should not be demanded, during full-speed trials, than 10 kilos. per sq. meter of grate surface per hour. This is practically equivalent to a consumption of 22.7 lbs. of coal per sq. ft. of grate per hour.

It has only been a few years since a forced-draft pressure of an inch of water was regarded as the limit to which the Scotch boiler should be safely forced for a continuous period. It was, therefore, natural that naval engineers of ten to twenty years' experience with forced draft at this pressure should be quite satisfied with the design of water-tube boilers which could be safely subjected to conditions that could not be withstood by the steam generators of the Scotch type.

By reason of the fact that not only the bent-tube, but even the straight-tube type of boiler can now be subjected to three times an inch water pressure for continuous periods, it is going to be as difficult a matter to do away with the water-tube boilers as it was to install them. All navies will therefore devote time, energy and thought to effecting improvements in the design and in the construction of water-tube boilers rather than in looking for reasons why there should be retrogression to the Scotch type.

The fact also that the water-tube boiler not only can be repaired in less time than the Scotch design, but that in the reboilering of ships it will not be necessary to interfere with the structural arrangements of the vessel, constitutes a military advantage that must be given great weight in comparing the relative value of the two types.

THE BOILER OF TO-MORROW.

Assuming, then, that the large straight-tube type of boiler has come to stay, and admitting the inability of this type to stand forcing to the extent to which the small bent-tube can be subjected, it seems logical that the next step in the development of the steam generator should be the adaptation of the straight-tube boiler to severe forced-draft conditions. This can only be effected by an extended, thorough and conscientious series of experiments to determine more accurately the following properties of the boiler:

1. The nature of the circulation of the water.
2. The character and extent of the baffling.
3. The best form of element.
4. The proper location and size of the downcast.
5. The simplest and most efficient manner of superheating.
6. The form and arrangement of the reservoirs or drums for containing for a brief period the liberated steam, and the provisions for liberation of the steam.

Other factors might also be considered, as follows:

1. The size of combustion chambers.
2. Facilities for repairs.
3. Ease of operating and overhauling the appurtenances.
4. Rapidity in getting up steam.

One of our leading shipbuilders has said that, at least in the merchant marine, the limit of speed under existing conditions has practically been attained. This expert maintains that the weight of reciprocating engines cannot be reduced, and that likewise the boiler weights under existing conditions are at a minimum. What more attractive then, for the merchant marine than a reduction in weights by the development of a boiler that can be safely and economically operated at greater capacities than those commonly used?

In the naval service particularly there should be a still greater field for a straight water-tube boiler that could withstand high forced-draft pressures. It has been estimated that the maximum speed, and therefore the maximum boiler power of the naval vessel, is required only for a fraction of 1% of her steaming career. As coal consumption during that limited time may be absolutely dis-

*From the "Journal of the American Society of Naval Engineers."

regarded, it is capacity and endurance that should be sought, rather than economy and efficiency under such extreme circumstances. It is economy at cruising speeds, combined with the ability quickly to secure the highest power that should be the controlling factors in boiler design for warships.

As it is a fact that in a boiler with a large combustion space the loss in efficiency under forced-draft conditions is principally due to the increase in temperature of the escaping gases, the suggestion is made that, for the merchant marine at least, a system of heating the air requisite for combustion will be necessary to secure economical efficiency at the increased capacity.

In an 18-knot battleship the boiler has been installed for the day of battle, and if maximum power could be secured at that critical time no consideration should be given to the question as to how much it cost to secure this capacity.

Under these conditions the ideal battleship installation should be so reduced that, allowing a margin of three or four boilers for cleaning, repairs, disablement, poor coal or inefficient stoking, the cruising speed should require all the remaining boilers worked under natural-draft conditions.

The following analysis of the boiler installation of the new "Maine" shows that could 30 HP. be developed per sq. ft. of grate, the boiler installation might be reduced one-half, provided endurance under forced-draft conditions could be assured. This vessel has 24 Niclausse boilers with 56.4 sq. ft. of grate surface and 2,421 sq. ft. of heating surface in each boiler.

of her boilers, or less than half the boiler-power installation, should develop the maximum designed power.

This practical and reasonable proposition has been stated in order the more graphically and the more forcibly to present the nature and the importance to the naval world of the extended series of tests that have been made by a board of naval officers using a Hohenstein water-tube boiler. It will be seen later that the boiler capacity required for the "Maine," with the proposed reduction in

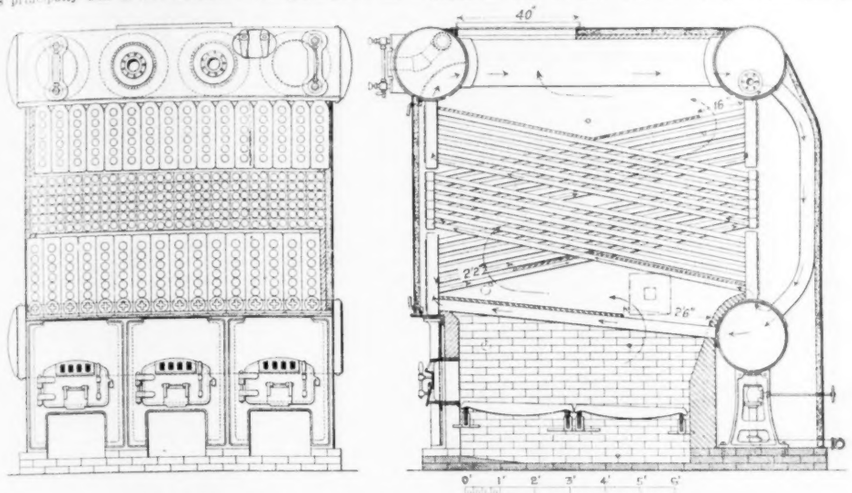


FIG. 1. FRONT AND SECTIONAL VIEWS OF HOHENSTEIN EXPERIMENTAL MARINE WATER-TUBE BOILER.

boiler installation, has repeatedly been exceeded under this experimental boiler.

THE HOHENSTEIN MARINE WATER-TUBE BOILER.

This boiler is undergoing what is probably the most extended series of official tests ever accorded a water-tube boiler. With the exception of an interval of a few months during which the transition from a coal-burning installation to an oil-burning plant was effected, the boiler has been subjected by the Hohenstein Boiler Board and the Liquid Fuel Board to continuous tests since April, 1901. The author of this article has assisted at every test conducted during the last six months. All the data has been recorded by employees of the Bureau of Steam Engineering or by persons connected with the naval service. Under the direction of the Liquid Fuel Board the writer has had general charge of the navy crew during the time that the oil tests have been conducted. While there have been 33 official tests made with oil as fuel, there have been at least 50 additional preliminary trials that have been made by the several inventors to test their installations. There were 17 official tests with coal as fuel, and many preliminary tests under various conditions of forced draft.

in diameter; a rear drum, 24 ins. in diameter, and four connecting drums, each 16 ins. in diameter. There is also a lower rear mud drum, 24 ins. in diameter.

Tubes.—There are sixteen 4-in. tubes 7 ft. long, 384 2-in. tubes 9 ft. long, and 15 5-in. downtake tubes which are connected to the rear steam drum and to the mud drum.

Heating and Grate Surface.—There are 2,130 sq. ft. of heating surface and 50.14 sq. ft. of grate surface. Ratio of heating surface to grate surface, 42.5 to 1.

Floor Space.—9 ft. wide, 10 ft. 11½ ins. deep.

Height over all.—12 ft. 6⅝ ins.

Volumes.—Water at steaming level, cu. ft... 142
Steam space, cu. ft..... 50
Furnace above grate bars, cu. ft... 121.14

Weights.—Boiler and fittings, excluding uptake and smoke pipe:

With water, lbs..... 54,127
Without water, lbs..... 46,908

Weights per sq. ft. of heating surface at steaming level and at 275 lbs. pressure:

With water, lbs..... 25.4
Without water, lbs..... 21.8
Water per sq. ft. grate surface, lbs..... 1,080

Ratios.—Area of grate to area of air spaces (average for all the tests with coal), 1 to .57.

Dimensions of smokestack:

Height of stack above the grate, ft..... 70
Cross-section of smokestack, sq. ft..... 8.73

Ratio of smoke pipe area to grate area, 1 to 5.75.

SPECIAL FEATURES IN DESIGN.

The most noteworthy features in the design of this boiler are those affecting its endurance under ordinary service as well as under extreme forced-draft conditions, viz:

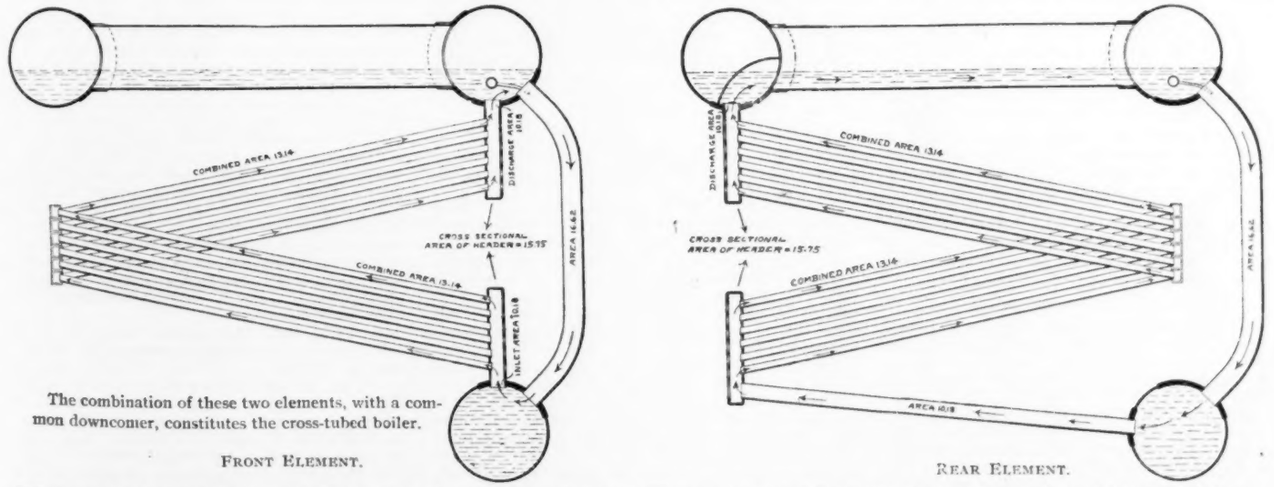
1. Circulation.
2. Elasticity of construction.
3. Accessibility for the cleaning and the renewal of tubes.

The following features, although of less importance, are yet essential to an efficient installation on board warships:

1. A large body of water within the boiler and drum, thus affording a steadiness of water level.
2. A large steam-liberating area, combined with a large steam space to insure dryness of steam.
3. A relatively large combustion space, the volume of which is 193 cu. ft., which permits the complete combustion of coal before reaching even the center of the furnace.

CIRCULATION.

Although declared unnecessary by many designers of water-tube boilers, this type of steam generator has a free area circulation throughout. The comparative areas of generating tubes and of downcomers is such that the carrying capacity of the latter is equal to the combined capacities of the generating tubes supplied. This has been accomplished without complexity of sizes, there being only two sizes of generating tubes, one of 4-in. and another of 2-in. Incidentally it might be added that this principle of free-area circulation is probably secured in the small bent-tube boilers that have shown themselves capable of standing a high degree of forcing. In the boilers of the bent-tube class, which are not provided with external downcomers of large area, an equitable proportion of generating tubes probably act as downcomers.



The combination of these two elements, with a common downcomer, constitutes the cross-tubed boiler.

FRONT ELEMENT. REAR ELEMENT.

FIG. 2. SEPARATION OF THE ELEMENTS IN THE HOHENSTEIN BOILER TO SHOW CIRCULATION AND ELASTICITY OF CONSTRUCTION.

Each of the boilers of the "Maine" should be capable of developing 670 HP. when burning 24.62 lbs. of coal per sq. ft. of grate, and this ought to be done under favorable natural-draft conditions. Each boiler should develop 480 HP. with easy firing, and when burning only 15 lbs. of coal per sq. ft. of grate. Under the latter condition eight of her boilers should give her a cruising speed of 12 knots even in a moderate sea. Could her boilers be forced to the extent of developing 28.4 HP. per sq. ft. of grate, ten

DESCRIPTION OF HOHENSTEIN BOILER.

The boiler is of 750 estimated HP. and was built to meet the requirements of the "Denver" class of cruisers as regards floor space, height and weight. It is admitted that the conditions as to boiler installation are as severe in the case of these cruisers as are likely to be met in any type of warship.

Drums.—There are six steam drums, forming a double hollow parallelopipedon. There is a front drum, 24 ins.

The kinetic energy of feed-pump discharge is conserved by nozzles in the feed line pointing into the downcomers. Then, through the downcomers the water travels at a comparatively cool temperature into a mud drum, whence it rises through a cross system of tube elements. This feature of feeding into the bottom of what corresponds really to a rear-header is termed by the designer the "loop system."

The numerous tests have demonstrated that there is an

assured circulation of water under all the conditions to which the Hohenstein boiler has been subjected, despite the fact that there are obvious restrictions to the circulation in the length of the circuit and the change of direction of the flow due to the introduction of a junction box. As for the objection urged to the use of this junction box, it may be pertinent to state that in the Belleville design there are practically a half-dozen junction boxes in the circuit comprised in a single element. If the contention of those who believe in an assured circulation in the Belleville design can be maintained despite the use of several junction boxes, then valid objection cannot hold to the introduction of a single junction box in this design.

The results secured, rather than the broad claims made, are the foundation for the belief that there is merit in the free-area circulation and the "loop system." It is therefore probable that this boiler or its development will yet play an important part in determining the approved type of naval boiler for the to-morrow.

ELASTICITY OF DESIGN.

The tubes, instead of being expanded into rigid headers at both ends, are so arranged that at least one end of each tube is expanded into a junction box. This junction box is free to accommodate any irregularities in the expansion and in the contraction of the tubes expanded into it. This also relieves the drums of the severe strains of the rigid headers found in some designs. During a recent test the front casing was removed and fires were lighted under the cold boiler. It was observed that there was a displacement of one of the lower front junction boxes to an extent of about ⅛-in. in the vertical plane.

ACCESSIBILITY OF TUBES FOR CLEANING AND RENEWAL.

The headers opposite the tube ends are closed by composition plugs. The plugs for the lowest row of tubes are 4½ ins. in diameter and have 8 threads per in.; all other plugs are 2⅞ ins. in diameter and have 11½ threads per in. The threads are lubricated with graphite. Some of the plugs were made with tapering threads and depend for tightness on these threads alone. It was thought that the relatively high coefficient of expansion of the composition would cause the plug to be tight under steam and easily removable when cold. It was found necessary, however, to cut out some of these plugs when it was desired to examine the tubes, leading to the belief that the composition when expanded had taken a permanent set, much as cast iron does under similar conditions.

The other plugs were packed under the flanges with Merwarth gaskets, consisting of concentric copper and lead rings soldered together. The plugs secured in this way were more easily removed.

No zincs were used in the experimental boiler, neither are any of the parts galvanized. It seems likely that for service afloat with the likelihood of salt and of oil in the feed water that it will be necessary to fit zinc rings over the tube ends.

The 4-in. tubes, being exposed to the greatest heat, should naturally be the most often examined. As these tubes are expanded into a mud drum at the rear end, this requires the removal of but one set of plugs, those screwed in at the front. The removal of these plugs, however, required the effort of two men on a six-foot lever. This naturally suggests the advisability of substituting hand-hole plates, at least in the case of the 4-in. tubes. All tubes can be withdrawn from the front.

There is room between the downcomers and the rear-headers to remove plugs and cut out the tubes, so that no space behind the rear casing is required for this purpose.

The cleaning of soot from between the tubes must be accomplished with a steam lance from the side, therefore hinged doors might be fitted to expedite this work. It must be recognized that the crossing of elements renders the cleaning more difficult in this type of boiler than in the case of other designs. However, this cleaning has been done under the experimental boiler for the past two years, and the possibility and the practicability of keeping soot and ashes off the tubes has been demonstrated.

STEADINESS OF WATER LEVEL.

This has been particularly commented upon by the water-tenders of the crew of the "Rodgers," all of whom have had extended experience with torpedo-boat boilers. The water level has been so thoroughly under control that it has been customary in all the tests to bring the water in the glass to its original level at the end of each hour. No water cocks were fitted to the experimental boiler, and during many of the tests there has been but one gage glass in use. These experiments have conclusively shown the necessity of finding a water glass that will be reliable at 275 lbs. steam pressure, and that it would be economy to pay a very high price for such a boiler fitting.

QUALITY OF STEAM.

The average quality of the steam for the 31 tests, the records of which have been published, is .986. For the tests under forced draft where 2 ins. or more of water pressure has been used, the average quality of the steam has been .982.

At no time during these tests have soda, salt or oil been introduced into the feed water. The following table shows the weight of water used in the boiler under varying conditions and the relative areas of water level.

Height of water in gage.	Total weight of water, lbs.	Difference, lbs.	Area of water level, sq. ft.
0	8,588	...	....
1 in.....	8,869	281	68.2
2 ins.....	9,235	366	72.2
3 "	9,648	413	74.4
4 "	10,033	385	75.7
5 "	10,405	372	76.4

ENDURANCE OF THE BOILER.

The steaming hours of the boiler to February 14, 1903, inclusive, under the various degrees of draft during these tests, are as follows:

	Natural draft.	Forced draft, ins of water. 1	1¼	2	2¾	3	3¼	3¾
Hours	503	76	7	71	5	17½	4	4

In addition to this, according to data submitted by the Oil City Boiler Works, the boiler has steamed 170 hours during unofficial tests preliminary to the Government tests, of which 85 hours were under natural draft and an equal time under forced draft.

While the official tests have continued for a period of about 500 hours, it is but just to call attention to the fact that the boiler has actually been under steam at least twice that length of time. There has not been an inventor who has attached his appliance to the experimental boiler who has not used every pretext to make preliminary and unofficial tests. It has been the policy of the Liquid Fuel Board to encourage the making of these

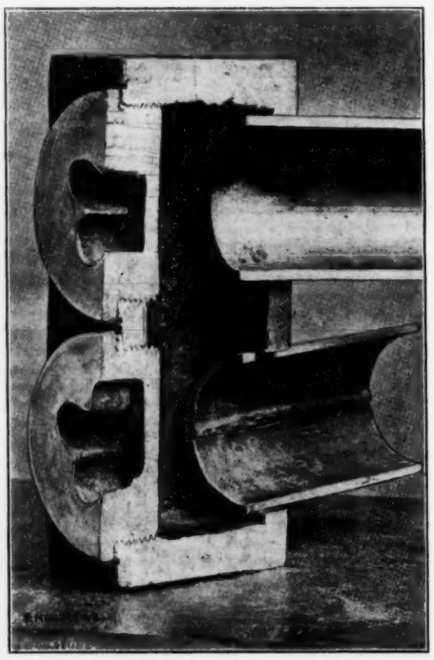


Fig. 3. Section of Junction Box for 2-in. Tubes, Hohenstein Boiler.

unofficial experiments upon the part of the several inventors, since valuable information has been secured by noting the failures as well as the successes of the various installations.

This experimental boiler has sustained more forced draft exceeding 1 in. of water than all the water-tube boilers in the service in other than torpedo vessels. The steam pressure carried in all the tests has been 275 lbs.

Beyond the sweating of a calked seam in the end of a mud drum, no leak has ever been detected in the boiler nor around the gaskets. The only repairs that have been made were to the linings of the casings and the renewal of gage glasses.

The equivalent evaporation from and at 212° F. has ranged from 106 lbs. to 709 lbs. per sq. ft. of grate surface per hour. This is practically an evaporation of 3.91 lbs. to 16.7 lbs. of water per sq. ft. of heating surface per hour. The maximum evaporation was obtained by burning oil, and was restricted only by the capacity of the feed pump. Most of the tests have been with oil fuel, during which the lower tubes have frequently been exposed to a temperature of 2,200° F.

CHARACTER OF THE FEED WATER.

For feed purposes the notoriously muddy water of the Potomac has been used. It must not be forgotten that the tests with this boiler have been carried on during every month of the year, and there are periods when the Potomac is probably as muddy as any river on the Atlantic coast. During the endurance trial of 116 hours the mud clogged the gage glass to such an extent that it became necessary towards the end of the run to blow down the glass at half-hourly intervals. Even during this test the efficiency of the boiler increased towards the end, clearly demonstrating that there had been sufficient circulation to prevent any deposit in the tubes.

No solvent of any description has been used in this boiler. From April, 1901, until January, 1903, a period of 21 months, there had been no scraping nor cleaning by mechanical means of the interior of the tubes. The boiler has been kept clean, however, but it was done by blowing down about a half-glass of water at the end of each test. After about every sixth test the tubes are cleared by pumping river water through the boiler. On Jan. 23, 1903, the boiler was completely opened for examination; the 4-in. and some of the 2-in. tubes were scraped internally with wire brushes to determine the condition of the metal. The boiler was found to be in excellent condition throughout, with no evidence of burning nor warping of parts.

THE CONDITION OF THE TUBES.

The interiors of the tubes were found coated with a deposit about the thickness of and closely resembling cement paint. In the downcomers, where the circulation was the least rapid, there were found cakes of mud ½-in. in thickness and several inches in diameter. There was about a bushel of deposit in the mud drum.

In the 4-in. tubes near the front headers were small lumps of deposit. When this deposit was removed there was no evidence of impairment of tubes either from corrosion or from overheating. For about 30° of arc at the bottom of the tubes there was a channel free from deposit, which ought to be convincing circumstantial evidence as to the efficiency of the circulation. The condition of the tubes was considered so satisfactory that, beyond removing the small cakes of deposit from the 4-in. tubes and scraping out the accumulation in the mud drum, no cleaning was attempted. It is possible that if clear feed water were used occasionally, combined with the introduction of some refined petroleum, this thin coating in the tubes would disappear.

INCIDENTS OF ENDURANCE.

When the boiler was placed at the disposal of the Hohenstein Boiler Board in April, 1901, the designer requested that it be not spared nor nursed in any way. The following incidents in connection with the extended series of tests ought to show that this boiler is neither sensitive to undue heating of parts nor dangerous when there is irregular feed.

On Jan. 11, 1902, while running a coal trial with 3-in. forced-draft pressure, the out-flowing tide exposed the end of the feed-suction pipe, making it impossible to supply feed water to the boiler. The fires were hauled as rapidly as possible, but as the fan blower was outside the air-tight compartment, it was several minutes before the blower was stopped. In the meantime the heated tubes were exposed to the blast of atmospheric air, at a temperature of about 76° F., blowing through the open furnace doors.

On five occasions during oil-burning trials the feed-water supply has failed, and the burners have been turned off, leaving the brick work in the furnace and combustion chambers white hot, with the water out of sight in the glass. On one of these occasions no water had been seen in the glass for a few minutes.

On Oct. 25, 1902, while under 3-in. forced-draft oil-fuel trial, and evaporating 28,000 lbs. of water per hour, the natural-draft evaporative capacity with oil as a fuel being about 12,000 lbs., there was a remarkable heating at the base of the stack. At the base of the stack a belt about 3 ft. wide and extending about two-thirds the circumference reached a cherry-red heat. This heated belt would probably have extended entirely around the stack if it had not been for the fact that about a third of the belt was exposed to a strong breeze which was blowing at the time. In order that the test might not be discontinued, the boiler was operated for at least half an hour after it was feared that the stack might settle or fall. At the time the senior member of the Liquid Fuel Board regarded the condition of affairs as the severest test to which the boiler had been exposed. That the front drum as well as the upper rows of tubes were exposed to excessive temperatures at this time cannot be doubted.

On Jan. 5, 1903, while running with 3 ins. of forced draft, a nipple of the feed-line pressure gage cracked. In order to continue this test, the feed pump was stopped with 8 ins. of water in the glass and a new nipple fitted without reducing the rate of combustion for the hour. When the feed pump was started again the water had been out of sight for about two minutes. The evaporation per sq. ft. of heating surface at this time was 10.33 lbs. That the water-tenders operating the plant remained in the closed fireroom and continued the 3-in. forced-draft test with water out of the glass and with repairs under way on the feed pump is evidence of their confidence in the boiler.

RECORDS OF COAL AND OIL TRIALS.

The accompanying Table I. (as to the performance of this boiler) was compiled from the annual report of the Bureau of Steam Engineering. It is submitted in support of the argument for the "Boiler of To-morrow." The horse-power has been estimated on a basis of 16 lbs. of

The tests with coal show that under favorable condi-

tions the boiler can develop about 1,800 HP., which is about 35.9 HP. per sq. ft. of grate surface within the limits of 2.5 lbs. of coal per HP.

The tests with oil show that 2,000 HP. may be developed from this boiler, using oil as a combustibe. Assuming 1 lb. of oil to be the equivalent in thermal efficiency of 1.5 lbs. of coal, which ratio has been established by the Liquid Fuel Board in the conduct of their extended series of tests, this capacity will require an expenditure of 2.7 lbs. of coal per HP.

Both tables are particularly instructive in showing the excessive loss in efficiency at the higher rates of combustion due to the high temperature of the escaping gases. These heat losses in the stack should show the necessity for heating the air requisite for combustion when attempting to secure maximum boiler power.

MODIFICATIONS IN DESIGN.

In a recent design of this boiler for installation in battleships and in armored cruisers the following changes are proposed:

1. Sectional wrought-iron boxes, 4 × 6¼ ins., to be substituted for the mud drum.
2. The front and the rear steam drums to be increased in diameter to 42 ins. and 30 ins., respectively.
3. Water walls to be provided in the furnace.
4. The spacing of the front headers and the junction boxes to be such that it will be possible for a steam lance to be inserted, to permit of cleaning from the front of the outsides of tubes.
5. The lower row of 4-in. tubes to be dropped 4 ins. at the rear, to facilitate the cleaning of lower baffling.

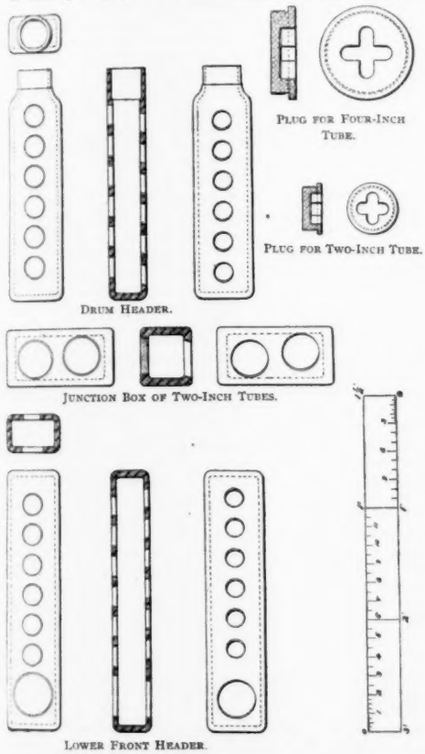


Fig. 4. Details of Headers, Junction Boxes and Plugs, Hohenstein Boiler.

TABLE I.—Tests of Economic Performance of Hohenstein Boiler.

Test, No.	HP.	HP. per sq. ft. grate surface.	Coal per hr. per sq. ft. grate surface.	Lbs. coal per HP.	Boiler efficiency.	Equiv. evap. per lb. of combustible from and at 212° F.	Difference between stack and fire-room temperatures, °F.	Loss in heat up stack, %.	Loss in economy due to incomplete combustion of C., %.	Ash-pit draft.
					COAL TRIALS.					
11	511	10.19	18.5	1.82	73.4	11.77	396	...	...	Natural
15	633	12.62	22.9	1.81	72.3	11.59	481	17.7	5.9	Natural
12	732	14.59	27.8	1.91	73	11.69	475	...	...	1 in.
5	963	19.21	35.5	1.85	72.8	11.41	572	15.9	10.4	1 "
13	1,347	26.86	53.4	1.99	67.2	10.79	631	...	...	2 ins.
17	1,622	32.35	72.2	2.23	59.4	9.53	866	28.3	3.4	3 "
					OIL TRIALS.					
3	609	12.14	...	1.26	71.5	14.43	397	13.2	2.4	Natural
5	732	14.59	...	1.28	70.4	14.22	445	14.4	0.7	"
13	747	14.89	...	1.29	71.1	14.35	479	15.4	0.4	"
7	1,090	21.74	...	1.39	65.8	13.29	627	15.1	1.2	"
1	1,229	24.51	...	1.44	62.8	12.70	584	17.3	7.7	1¼ ins.
2	1,515	30.21	...	1.51	60.3	12.18	657	20.1	6.4	2½ "
4	1,846	36.81	...	1.55	58.1	11.73	746	24.2	1.7	3¼ "
8	1,938	38.65	...	1.70	53.4	10.77	902	28.1	1.2	3¾ "

Hundreds of persons have been invited to witness these tests. Scores of experts, representing naval, maritime, manufacturing and commercial interests, have spent hours at the experimental plant. It has been recognized that it has neither been desirable nor possible to withhold for any length of time data that others might have a special interest in securing. It is fair to say that no more complete and exhaustive boiler tests have ever been conducted under absolutely naval auspices. Realizing that the real test of a boiler must be at sea, the conditions during all the tests have been made to approximate sea conditions as closely as is possible on shore. They will stand for a long time as evidence of the intelligence, the thoroughness and the fairness of the Navy Department in the conduct of official tests of appliances relating to the naval service, under the cognizance of the bureau of steam engineering.

THE MILITARY IMPORTANCE OF THE BOILER PROBLEM.

The boiler question grows in importance the more closely the subject is studied. The trend of naval thought in this direction may be evidenced by the following facts:

Over three years ago the British Admiralty appointed a boiler commission to investigate, among other subjects, the question of determining if an improved type of boiler could be found for the Royal Navy. This commission has not hesitated to demand the employment of naval ships in commission for the collection of comparative data upon the subject.

The Lords of the Admiralty have likewise employed the cruisers "Minerva" and "Hyacinth" during the past two years, for practically no other purpose than to test the endurance and the efficiency of the installation of Belleville boilers as compared with equal installations of Scotch boilers in ships of equal tonnage.

The German Admiralty is not only conducting comparative tests at Charlottenburg, but the commanders of the ships in commission have been specially directed to gather reliable data for the Berlin authorities as to the efficiency and the endurance of the leading forms of water-tube boilers.

The splendid work of M. Bertin in his investigation of the efficiency of marine boilers, and in carrying out the earnest wishes of the French Minister of Marine to secure definite data in regard to the boiler problem, shows how seriously the French Admiralty regard the subject.

The interest of the U. S. Navy in the subject has been evidenced by the Bureau of Navigation permitting the continuous employment for nine months of a torpedo boat and its complement as auxiliaries to the work of the Hohenstein Boiler and Liquid Fuel Boards. The detail of this torpedo boat has been permitted despite the fact that there has been an exceedingly urgent demand for both the boat and its crew during the past year.

In all navies the corrosion of boiler tubes is going on at a rapid rate, very often in an incomprehensibe manner. With impaired boilers, ships can neither reach the battle line nor do extended cruising, and thus the actual strength of all navies is more apparent than real by reason of the weakness of the boilers.

It is an oft-repeated story which tells of some warship and even of an ocean greyground hobbling into port with impaired boilers after an ocean voyage of less than a week.

Such facts must impress all naval experts with the realization of the proof that the naval problem of the hour may soon turn, if it has not already done so, in the direction of the problem of the boiler.

FURTHER INVESTIGATIONS OF WATER WASTE IN NEW YORK CITY.

In our issue of Feb. 5 we published a preliminary statement regarding an investigation of water consumption and waste in New York city, which was being made by means of the Cole-Flad pitometer, described in the same issue. The work in question is being carried on by the Department of Water Supply, Gas and Electricity, of which Mr. Robert Grier Monroe is Commissioner and Mr. Nicholas S. Hill, Jr., M. Am. Soc. C. E., is Chief Engineer. Mr. Hill has just sent a second progress report on this work to Mr. Monroe, the text of which is given below. We also reproduce one of the tables and a portion of the diagrams accompanying the report. In our issue of Feb. 5 we published a large table, showing the method employed in recording the data. The table printed herewith is a summary of the information given in the larger table. The accompanying diagram shows the variations in consumption throughout the 24 hours of some five days in February and March for that portion of New York city located south of Canal St., on Manhattan Island. It is notable as including the financial and an important section of the general office district of the city, and for having a resident or night population of only 11,000, against an estimated daily population of 114,000. The maximum and mini-

Table Showing Comparison of the Hohenstein with the Straight-Tube Boilers of the U. S. Naval Service.**

Names of boiler.	Size: Estimated HP.	Size: Grate area, sq. ft.	Size: Total heating surface, sq. ft.	Bulk: Weight of boiler in service, empty, lbs.	Bulk: Weight of boiler in service with water at steaming level. Boiler not, lbs.	Bulk: Ratio of projected area to grate area.	Bulk: Height over all.	Quality of steam: Steam liberating area expressed as a per cent. of total heating surface.	Quality of steam: Volume of steam space, cu. ft.	Circulation: Ratio of area of generating tubes to downcomers.	Circulation: Length of generating tubes expressed in diameters.	Sum of angles in bends of generating tubes, Deg.
Hohenstein, "Experimental."	750	50.14	2,130	46,568	54,127	1.97†	12′ 6¾″	3.52	50	1.58	108 129	405
Hohenstein, *"Battleship."	1,333	93	3,990	85,386§	97,689§	1.84	13′ 9″	3.73	177	2.01	108 129	405
Babcock & Wilcox, "Wyoming."	600	50	2,200	‡	‡	1.86	11′ 7″	1.36	33	7.57	52.5	240
Babcock & Wilcox, "Cincinnati."	1,000	63.3	2,480	53,400	62,640§	1.6	12′ 6″	1.71	55	7.3	26 48 24	240
Niclausse, "Nevada."	600	55	2,220	‡	‡	1.76	10′ 10¾″ (over dome)	1.13	42	5.5	26	280
Niclausse, "Maine."	666.7	56.4	2,421	‡	‡	1.4	14′ 8″ (over dome)	0.908	45	14.4	25.75	280
Yarrow, "Nashville."	...	25	1,000	14,938	18,748	2.32	7′ 10″	1.9	18.5	..	33.5	...

*Data furnished by Oil City Boiler Works. †No space required behind rear casing. ‡Not obtainable. §Estimated.

**For much of the data in this table the author is indebted to Mr. E. N. Janson, Bureau Steam Engineering, Navy Department.

mum temperatures preceding and during the period covered by the diagram were as follows:

	Temperature.			Temperature.	
	Max.	Min.		Max.	Min.
Feb. 21.....	38	20	Feb. 26.....	44	27
" 22.....	32	25	" 27.....	52	35
" 23.....	40	22	" 28.....	62	47
" 24.....	44	32	Mar. 1.....	50	30
" 25.....	38	25	" 2.....	41	28

The following is Mr. Hill's report:

Sir: I transmit herewith tables and curves showing the results of the waste inspection in Districts 1, 2, 3, 5, 6, 7, 8 and 9. In the previous report you received the data on Districts 1 and 2.

District No. 1 is bounded by 42d St., Lexington Ave., 34th St. and 6th Ave.; a typical residential and high-class hotel section.

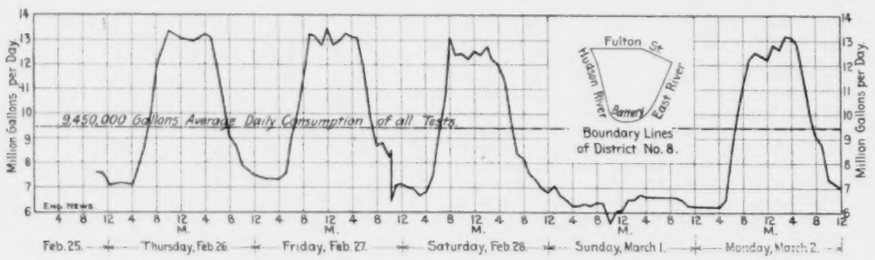


DIAGRAM SHOWING WATER CONSUMPTION SOUTH OF FULTON ST., MANHATTAN BOROUGH, NEW YORK CITY, FEB. 25 TO MARCH 2, 1903.

(See accompanying table for further figures.)

No. 2 is bounded by 86th St., East River, 80th St. and 2d Ave., being a tenement house district.

No. 3 is bounded by Grand St., East River, Market and Division Sts. This is a typical East Side tenement section.

Owing to the condition of the mains and valves, it was impossible to make the tests on the No. 4 District, which is bounded by Canal St., Broadway, Chambers St. and West Broadway, representing the dry-goods district.

No. 5 District contains a large number of moderate priced apartment houses. It is bounded by 142d St. on the north, Southern Boulevard on the east and south, and Alexander and Willis Aves. on the west.

No. 6 District contains a large number of apartment houses and private residences, and is bounded on the north by 96th St., on the east by Broadway, on the south by 86th St., and on the west by the Riverside Drive.

No. 7 is an irregular district approximately bounded on the north by the Southern Boulevard, on the east by the East River, and on the south by the East and Harlem Rivers. This district contains a gas works, a number of large factories and the yards of the New York, New Haven & Hartford Railroad. The barges and transports of this company take their water at this point. The resident population in this district is very small.

District No. 8, which is bounded on the north by Fulton St., on the east by the East River, on the south by the water front at the Battery, and on the west by the North River, is a representative office building section.

No. 9 is similar to the No. 6 District, lying on the upper west side, and bounded by 86th St., Broadway, 72d St. and the Riverside Drive.

The results of the examination in Districts Nos. 1 and 2 have already been reported. (See Eng. News, Feb. 5, 1903.—Ed.)

I submit herewith a condensed table of the results in all the districts so far surveyed. From this table it is interesting to note, first, that there is no apparent connection between the metered consumption and the total per capita consumption. As an example, in District No. 1, 43% of the water consumed is metered, while the gross per capita consumption on the total population is 121 gallons per day. In No. 2 District only 20% is metered, whereas the gross per capita consumption is only 37 gallons per day; and in the No. 9 District the metered consumption is but 11%, while the gross per capita consumption, based on total population, is 154 gallons per day. This indicates that the class of the population and the characteristics of the local industries, together with the percentage of non-resident population, have to be considered in interpreting the results. This is forcibly shown in the comparison made between the above named districts. In No. 1 District the non-resident population amounts to about 50% of the whole, where the percentage of metered supply is the largest, whereas in the other two districts named the non-resident population need not be considered. In addition to the above districts, I would call your attention to Section No. 5, where the metered consumption is only 5% of the total, and the gross per capita consumption is as low as 54 gallons per day.

The total revenue for Manhattan and The Bronx is 6.73 cts. per 1,000 gallons. The metered rate in New York City is 13.3 cts. per 1,000 gallons, approximately twice the actual revenue derived. This would indicate that a reduction in the metered rate would tend to popularize the introduction of meters, and, at the same time, reduce the waste due to plumbing leakage. A rough estimate, based on the plumbing leakage reported in the territory examined to date, shows that the total plumbing leakage in the Boroughs of Manhattan and The Bronx will probably amount to 32,000,000 gallons per day. While this is not definite or conclusive, a more thorough house to house inspection would probably develop a larger waste. It is conservative to estimate that the total will at least equal the figures given. At the metered rate of 13.3 cts. per 1,000 gallons, this leakage represents, approximately, $1,560,000 per annum. An appropriation equivalent to the annual loss thus sustained would meter a large proportion of the city. The effect of the meters would be to reduce the waste, and the city could probably, under these conditions, afford to sell water for less than at the present time.

We have not been able to go into a final and determinate examination of the leakage in mains, except in District No. 1, where no leakage was found. We have, however, examined the sewers, conduits and other underground structures, and have been unable to locate any sewer leaks. Owing to the condition of the service connections, which have not been supplied with check valves, and the age of the valves in the lower sections of the city where the largest leaks would be apt to occur, this investigation is impossible without the outlay of a large amount of money in repairs and changes. We are at work now on subdividing several of the districts, for the purpose of continuing this examination.

The ratio of the minimum night consumption to the average for twenty-four hours, in the districts so far surveyed, runs from 50 to 90%, which appears abnormally high. In District No. 1 a very careful survey showed a large number of tanks which were filled during the night hours, and which, owing to the low pressure in this area, did not overflow. This inspection, in conjunction with the sewer inspection, which showed little or no leakage through the spurs to the sewer, would indicate that the filling of the tankage accounts for the high ratio. There is a large amount of tankage throughout Manhattan which is being filled at night, and which will in part account for this high ratio, but, on the other hand, out of about 1,500 tanks examined, 56% were without ball cocks, which clearly indicates that there is considerable waste due to the overflow from the tanks after they are filled.

Another source of waste is due to running faucets during the winter months, for the purpose of preventing freezing of plumbing, and it would be interesting to make experiments in the districts already covered, in the spring and summer months, to compare the consumption curves, for the purpose of obtaining a comparison.

Mention was made heretofore regarding the economy of meters, and undoubtedly the extension of their use would be the most economical way of preventing the sources of waste just mentioned. If it is possible, the department should be provided with an annual appropriation to supply the necessary inspectors to check a large proportion of the waste enumerated. This is an alternative which might be considered expedient.

The suggestions given above are not conclusive, but the results so far obtained indicate the advisability of working on the lines mentioned. When further data is received, supplementary reports will be furnished you, which I trust will be more conclusive.

Summary of Results of Water Waste Inspection in Certain Districts of New York City, to March, 1903.

	Total acres.	Area waste district.	%	Total consumption daily.	Gallons metered daily.	%	Gallons leakage in fixtures.	%	Population. Resident.	Population. Total.	Gross, per capita consumption. Resident.	Gross, per capita consumption. Total.	Total revenue. Metered galls., approximate.	Total revenue. Metered & unmetered, gallons; Yearly.
Borough of Manhattan.														
Dist. No. 1.....	....	127	...	1,470,000	638,000	43%	42,429	3%	8,396	12,156	175.0	121.0	$0.0720	$49,115
" " 2.....	....	70	...	1,440,000	293,000	20%	389,000	26%	38,906	38,906	37.0	37.0	.0088	51,865
" " 3.....	....	168	...	5,400,000	940,000	17%	672,500	12%	90,000	90,000	60.0	60.0	.0498	98,485
" " 6.....	....	58	...	700,000	160,500	21%	87,200	11%	10,164	10,164	74.8	74.8	.0697	19,800
" " 8.....	....	230	...	9,450,000	5,379,000	56%	423,764	5%	11,000	114,000	860.0	83.0	.0768	267,832
" " 9.....	....	75	...	1,366,000	156,300	11%	119,500	9%	8,872	8,872	154.0	154.0	.0520	25,895
Total	12,576	728	5.8	19,886,000	7,566,800	38%	1,714,393	9%	167,338	274,098	119.0	73.0	$0.0707	$512,492
Borough of The Bronx.														
Dist. No. 5.....	....	174	...	1,750,000	86,000	5%	329,479	19%	32,200	32,450	54.3	54.0	$0.0674	$43,023
" " 7.....	....	260	...	1,600,000	551,900	35%	148,200	9%	3,076	6,076	521.0	263.0	.0278	16,238
Total	26,522	434	0.0	3,350,000	637,900	19%	477,679	14%	35,276	38,526	95.0	87.0	$0.0484	$59,261
Total for Manhattan and The Bronx to March, 1903.														
Grand tot'l	39,098	1162	0.0	23,236,000	8,204,700	35%	2,192,072	9%	202,614	312,624	115.0	74.6	$0.0673	$571,753

Estimated (in round numbers) Total Leakage in Fixtures Alone.

Manhattan....	1,714,393 gallons.	is 5.8% of	29,550,000 gallons.	daily, which at meter rate equals	$1,440,000 per annum.
The Bronx.....	477,679 gallons.	is 17.65% of	2,710,000 gallons.	daily, which at meter rate equals	132,000 per annum.
Total estimated leakage*.....			32,260,000 gallons.	daily, which at meter rate equals	$1,572,000 per annum.

*Based on population.

A STREET RAILWAY FRANCHISE has just been granted to the New York City Interborough Railway Co. for a number of lines of surface railway, mostly in Bronx Borough, but connecting at various points with the Manhattan Elevated and the new Rapid Transit railways, and crossing a number of bridges. The franchise appears to have been drawn with great care, and is designed to conserve the interests of the city in many important respects. It is to extend for a period of 25 years, with the right of renewal for 25 years more, upon a "fair valuation" of the franchise. The valuation is to be made by three appraisers chosen in the usual manner, who may have access to the books of the company. At the end of the grant or its renewal there shall be a fair valuation of the street railway system, not including the value of the franchise, and on the payment of such valuation the property is to pass to the city. The company is to pay the city 3% of its gross receipts for the first five years of the grant and 5% for the next 20 years, but regardless of receipts the annual payments must be at least $15,000 and $30,000 a year, respectively, besides which it pays $4,000 a year for each of four bridges for the first five years, $4,500 for the next five, and so on up to $6,000 a year. The company agrees to keep the space between the tracks and for 2 ft. outside in permanent repair, and free from snow and ice; it also agrees that the whole width of the streets up to 60 ft. shall be watered by it at least three times in 24 hours when the thermometer registers above 35° F. The city reserves the right to grant any other company the right over streets within 1,000 ft. of the lines of the company, and also the right to use the tracks and power of this company over bridges and viaducts; provided, in the latter case, the second company pays the legal rate of interest on not over one-half of the cost of the tracks and wires or conduits so used, and the actual cost of the power consumed. The franchise ordinance was published in full in the New York "City Record" of April 2.

THE RAILWAY MILEAGE OF JAPAN at the end of 1900 was 4,025 miles, of which 1,059 belonged to the Government. The total outlay for construction of permanent ways was $103,286,292 for the private railways, and $61,216,447 for those of the Government. The total net profit of the Government railways in 1900 was $4,192,225, while that of the private railways was $8,256,064. Although the profit in both cases is good, it is low compared with the returns on capital invested in other Japanese industries. The greater part of the income is from passenger traffic. On the Government railways in 1900 freight receipts were $2,734,020, as compared with $5,418,240 passenger receipts. Private companies in 1900 received $5,861,460 from freight and $39,406,740 from passengers.

THREE NEW GEOLOGIC FOLIOS are ready for distribution at the regular prices by the Director of the U. S. Geologic Survey, Washington, D. C. They are Folios No. 83, 85 and 86. No. 83 includes New York city, Jersey City and surounding country. No. 85 is the Oerlich's Folio, including part of South Dakota and Nebraska. No. 86 is the Ellensburg Folio, State of Washington. No civil or mining engineer in general practice can afford to be without the folios covering the districts within which he is practicing. The price of each folio is 25 to 50 cts., depending upon its size.